LEAN MANAGEMENT IN HOSPITAL PURCHASING PROCESS: A CASE STUDY

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Palabras clave: Auditoría externa, Independencia, Auditor, Contabilidad financiera.
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Key words: lean management, hospital, process, costs, service
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Resumen
Los sistemas de la asistencia médica engendran costes encima de límites razonables, y asegurarse de niveles altos de servicio, especialmente en zonas remotas, llevan a costes aún más altos. Basado en un enfoque Lean, este artículo tiene como objetivo desarrollar un nuevo sistema de compra en hospitales. Se utilizó el estudio de caso de un hospital en una zona remota de Europa con altos niveles de incertidumbre de la demanda. El proceso más común de la compra de materiales se asigna y se analizaron, y malgasta es identificado. Las conclusiones muestran que es posible reducir el tiempo del proceso de compra por más del 98 por ciento. Un nuevo modelo de contratación para el modo de comprar analizado también es presentado.

Palabras clave: Lean management, hospital, proceso, costes, servicio

Abstract
Health care systems are generating costs above reasonable limits. Assuring high service levels, especially in remote zones, leads to even higher costs. Based on a lean approach, this research aims at developing a new hospital purchasing process. A case study of a public hospital in a remote European area with high levels of demand uncertainty is used. The most common purchasing process is mapped and analysed, and waste is identified. Conclusions show that it is possible to reduce the purchasing process time by more than 98 per cent. A new overall organizing model for the analysed purchasing option is presented.

Key words: lean management, hospital, process, costs, service
INTRODUCTION

The public sector is becoming a research focus and hospitals in particular have been the target of much of this effort (see, for instance, Dobson et al. (2009), Mutter et al. (2010) or Werner et al., (2011)). Although the reduction of costs has already been analysed (see, for instance, Milne and Hoorne (2010), Northcott and Llewellyn (2002) or Chandra et al. (2011)), it has been usually approached from the perspective of efficiency of employees or even the management of flows (see, for instance, Wilson et al. (2005) or Hanne et al., (2009)). Not much research has been performed in terms of purchasing processes, and even less in terms of these processes in hospitals that, for instance due to its location, have extra constraints.

The purpose of this research is to analyse the purchasing process of a public hospital with special characteristics – located in an island the middle of the Atlantic, with a very unpredictable demand level, physically distant from its suppliers, and dependent on unreliable transportation, - and identify how that process may be improved in order to increase speed and reduce cost.

Taking into consideration the purpose of this research, focussed on value and waste reduction, a lean approach will be used. Process activity mapping is required and it allows the analysis not only of how the purchasing process is performed, but also where time and cost wastes emerge and may be reduced.

As the scope of the research is the purchasing process in a specific hospital, Hospital do Santo Espírito in the Azores Islands, the methodology adopted is case study research. As the topic is recent, not much explored, and focussed on an isolated situation, according to Yin (2003), this is the most appropriate research methodology.

Concerning the case study, and according to the conceptual approach adopted, the customers of the process and the value the process creates for them are defined. Then, the purchasing process is mapped, the time and resources used at each step are identified, and the activities are classified. Afterwards, the process is analysed and alternatives iares developed so that the time and costs associated to that process may be reduced. It is also a goal of the proposal to at least maintain the process's effectiveness level.

Accordingly, this article starts with a brief literature review on lean management and the identification of the research question, as well as the propositions to be analysed. Then the article continues with a condensed description of how the Portuguese Health System works, the natural singularities of the analysed hospital, and the mapping of the process at its present situation. The analysis of the process and of its activities is the following objective. Lastly, proposals are developed and conclusions on the research questions and the purpose are developed. Also included in the conclusions are the limitations to the results obtained as well as topics for further research in the field.

LITERATURE REVIEW

Lean Management, as initiated by Ohno (1988), identified by Schonberg (1986), and developed by Womack and Jones (2003), aims at customer value. Although some initially focussed on efficiency and waste reduction, Lean Management is focussed on
what is relevant for the customer. From that point forward all efforts are made to reduce what does not contribute to this goal: waste.

Waste, and many types of waste can be found (Ohno, 1988), is the result of a miss reading of what is important to the customer. It leads companies to focus on irrelevant characteristics of the product. Sometimes also happens that companies simply focus on how to produce or supply the service is a more efficient way and forget the customer (Womack and Jones, 2003). Effectiveness is the measure of the customer, of how his requests are fulfilled. Efficiency only emerges if resources are used in a more rational way as long as effectiveness is still fulfilled.

Value is the critical point in lean thinking. Therefore, the provider can enhance value to the customers by adding features to the product or service and/or by removing wasteful activities. These consume resources and represent costs without adding value to what is produced. As value has to be defined by the customer, it cannot be seen as the opposite of waste.

Activities have to be enhanced if the cost involved is higher than the increase in value they represent, or removed if no value is produced. It means that a cost-value proposition (Hines et al, 2004) should be analysed. The equilibrium represents the cost the customer is available to pay for the offering. Therefore, the higher the cost-value proposition offered the more attractive it will be to the customers.

Although initially, with Ohno (1988), the approach was focussed on lean operations management, contemporary approaches expand the concept of Lean Thinking to several other sectors, including the services area. In fact, it can be found in more obvious areas such as supply chain management (Simonsa and Taylor, 2007), but also already in services such as healthcare (Papadopoulos, et al, 2011), universities (Hines and Lethbridge, 2008), logistics (Jones et al, 1997), criminal investigation (Ahluwalia and Srinivasan, 2004), courts of law (Hines et al., 2008; Martins, 2010), municipalities (Arlbjorn et al, 2011), or government agencies (Radnor, 2010).

The application of lean cannot be the same in the manufacturing area and in the services area, but service companies can benefit tremendously from it (Allway and Corbett, 2002). Services natural characteristics, such as customer influence, intangibility, inseparability, heterogeneity, perishability, and labour intensity (on service characteristics see, for instance, Nie and Kellogg (1999)) require an adjusted attitude as highlighted by Johnston (2005). Nonetheless, the overall approach and goal remain the same. With the current situation of economic crisis and the need to reduce costs, going lean can emerge as an appropriate solution to keep (and even improve) effectiveness while costs are reduced.

Public services or services provided by non-profit organizations can also be approached from a lean perspective. Although the profit is not the goal, the approach is similar as the lower the costs, respecting the cost-value equilibrium, the wider the population that can be served by those entities or the higher the value proposition offered (Martins, 2010).

Hospitals and health services are an area that has been explored in terms of lean management. Many recent and some not so recent articles (for instance, Garavaglia et
al., (2011), Papadopoulos, et al., (2011), Ben-Tovin et al. (2007), Stuenkel and Faulkner (2009) or Manos et al., (2006)) can be found in literature on this topic. Nonetheless, all of them focus on quite stable processes and conditions. Although a lean approach is more adjusted to stable environments (Womack and Jones, 2003), it might be interesting to analyse if it can be used to achieve value and cost benefits in more uncertain healthcare processes. Accordingly, an initial research question (RQ) is as follows:

RQ1: Is it possible to apply lean management principles in more uncertain healthcare processes?

In order to do so, a case study of a hospital in the Azores islands will be analysed – Hospital do Espírito Santo. The purchasing process will be analysed as this hospital is geographically isolated and distant from its mainland suppliers and supply is dependent on weather conditions.

If RQ1 is true, from a time and cost perspective, and taking into consideration the purchasing process, it is also relevant to analyse the following research question:

RQ2: Is it possible to reduce time and cost in the purchasing process of Hospital do Espírito Santo?

The longer the lead times the higher the inventory required to satisfy customers with the same service level. Therefore, a reduction of the process time would result in an inventory level lower than before and also lower costs.

DATA AND METHODS

As a case study approach will be used, Yin’s (2003) recommendations will be followed. Initial data concerning the national purchasing system was obtained from the Portuguese laws. More detailed information on the details of the Hospital do Santo Espírito was collected from local interviews.

The goal of this research is reduction of time and cost in the purchasing process. Taking these goals into consideration, according to Bicheno (2004), process activity mapping is the most appropriate lean tool to be used.

Hospital materials were compared and analysed. Primary data from the hospital was used. Pharmaceutical products were found to be responsible for about 70% of all consumptions in the hospital. This percentage is quite stable throughout the years.

Several purchasing processes can be used, depending on the product and the specific situation. It was found that in the analysed case study 52% of the purchasing situations were performed according to the “Competition coordinated by the Central Healthcare Administration” option.

According to the findings it was decided to map pharmaceutical products in a “Competition coordinated by the Central Healthcare Administration” purchasing process.

The pharmaceutical products were analysed through a Pareto Rule. The A products were selected for analysis. Although the process sequence is similar to all products, a
random product was selected to be the basis for information on the time spent in each activity – *Tenecteplase 10000 UI AMP*. Latter it was found that several products are purchased at the same time. Therefore, the periods of time identified not only apply to the product under analysis but also to all the other products purchased at the same time regardless their classification as A, B, or C products (according to a Pareto Rule).

The sequence mapped starts when the information system is asked for shortages and end when the bill from the supplier is send to the Accounting Department.

Technology used was considered, as well as interviews with participants in the process to clarify details of activities performed throughout the process. The mapping process was developed according to direct observation and interviews. Employees were not totally aware of the purpose of the research so that it would not influence their natural behaviour.

The final process proposals take into consideration not only possible technological upgrades but also the limitations of the Portuguese law.

CHARACTERISING THE CASE STUDY

The hospital under analysis the Hospital do Santo Espírito located in one of the Azores islands, “Terceira”. This hospital serves not only the patients from the island but also all coordinates demand from four island. It is also the international referred location for patients on ships in the Atlantic Ocean and on airplanes between the American (central and north American) and the European continents.

Demand is unstable as well as supply. Due to weather conditions the island can be isolated both by air or sea for several days during the winter.

Products are usually transported using maritime transportation. There are three companies that assure maritime transportation from the main land to the island, each with a weekly shipment. The trip takes, on average, seven days. If weather conditions are favourable it might require only 6 days.

Although the policy of the hospital is to keep inventory for three months of consumption, the variability of pathologies is such that urgent request are sometimes needed. These are usually transported by air from the main land and require about 1 day to arrive.

There are also local suppliers but these do not have inventory of all products required. In fact, they support inventory of products that are demanded not only by the hospital but also by pharmacies and health centres. There are products that are not kept by these local suppliers, mainly if they have short expiry dates and variable demand.

This hospital, as all other public hospitals in Portugal, does not negotiate directly with the suppliers. Although it can happen in specific situations it is not the standard procedure. Negotiations are performed by the Central Healthcare Administration and information concerning the products available and their prices is made available to all hospitals through their website. This is the reference all hospitals should follow.
PROCESS MAPPING

*Identifying the customer and value*

As each process is (should) be focused on generating value according to its customer(s), these have to be identified.

It is possible to identify customers for the pharmaceutical purchasing process at several different levels. The immediate customers are the hospital departments that will use the product to provide healthcare services. These require product availability on time and in the correct quantity to be able to perform their tasks.

A second level of customers is the final customers. These are the patients of the hospital. Their families could also be included here to some extent. Both the patients and their families require product availability. The cost variable is not included here as the Portuguese healthcare system, at the level of materials consumption during services provided by hospitals, is free of charge for the patients.

At a third and wide-ranging level, the overall population could also be considered a customer of this process. These are the ones that not only use the services, and therefore require availability and effectiveness, but also finance the system through their taxes, and therefore want the system to be as efficient as possible.

It is then possible to conclude that the purchasing process of the hospital under analysis has to generate value to different levels of customers – internal departments, patients, and the overall population. To these customers value is not only having products available on time, but also availability in a cost-efficient way.

*Mapping the purchasing process*

According to the “Competition coordinated by the Central Healthcare Administration” process and the specific product selected, the sequence of mapped activities is shown in Table 1.

The process starts with a request on the information system to identify inventory levels (activity 1). The lists are then printed and manually analyzed for shortages (activity 2). As activity 1 lasts for about one week, once it is produced data is no longer valid and has to be manually adjusted considering the consumption level of that week (activity 3).

Once the shortages are fully identified, an employee accesses the Central Administration website to identify the available suppliers, the price of the product and taxes applicable (activity 4).

Data collected from the website is then analyzed by the head of the Pharmaceutical Department. The most suitable suppliers are chosen and a “purchasing request” produced (activity 5). This document is physically sent to the Purchasing Department (activity 6) and the employee returns with a copy of the document stating that it was delivered. The employee of the Purchasing Department registers the document entry (activity 7).
<table>
<thead>
<tr>
<th>N.</th>
<th>Activities</th>
<th>Type of activity</th>
<th>Area</th>
<th>Distance</th>
<th>Time</th>
<th>Useful time</th>
<th>Wasted time</th>
<th>N. persons involved</th>
<th>Obs.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Conclute system looking for shortages</td>
<td>VA</td>
<td>Pharm</td>
<td></td>
<td>17th Nov. 10:30h/ 24th Nov. 11:00h</td>
<td>7 days</td>
<td>0 min</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Identify shortages</td>
<td>VA</td>
<td>Pharm</td>
<td>1mt</td>
<td>24th Nov. 11:00h to 13:00</td>
<td>2 hours</td>
<td>0 min</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Manual adjustment of quantities</td>
<td>NVA</td>
<td>Pharm</td>
<td>2mt</td>
<td>14:00h to 16:00</td>
<td>2 hours</td>
<td>0 min</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Consult Central Administration website</td>
<td>NVA</td>
<td>Pharm</td>
<td></td>
<td>25th Nov 9:00h to 11:00h</td>
<td>2 hours</td>
<td>1 hour</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Produce &quot;purchasing request&quot;</td>
<td>VA</td>
<td>Pharm</td>
<td>2mt</td>
<td>24th Nov. 14:00h/ 26th Nov. 13:55h</td>
<td>6 hours and 55 min</td>
<td>0 min</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Send &quot;purchasing request&quot; to Purchasing Department</td>
<td>NVA</td>
<td>Pharm</td>
<td>229mt</td>
<td>24th Nov. 13:55h</td>
<td>5 min</td>
<td>0 min</td>
<td>1 Pharmacy administrative person</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Reception of &quot;purchasing request&quot;</td>
<td>NVA</td>
<td>Purch</td>
<td></td>
<td>26th Nov. 14:00h</td>
<td>5 min</td>
<td>0 min</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Adjust &quot;purchasing request&quot;</td>
<td>NVA</td>
<td>Purch</td>
<td></td>
<td>26th Nov. 14:30h</td>
<td>2 hours 1 day and 30 min</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Introduce &quot;purchasing request&quot; into information system</td>
<td>NVA</td>
<td>Purch</td>
<td></td>
<td>28th Nov. 09:30 to 12:35h</td>
<td>5 hours and 55 min</td>
<td>1 hour</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Confirm &quot;purchasing order&quot;</td>
<td>NVA</td>
<td>Purch</td>
<td>11,1mt</td>
<td>02nd Dec 14:30h</td>
<td>2 min</td>
<td>4 hours and 28 min</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Send &quot;purchasing order&quot; to meeting room</td>
<td>NVA</td>
<td>Purch</td>
<td>8mt</td>
<td>02nd Dec 16:00h</td>
<td>2 min</td>
<td>1 hour and 30 min</td>
<td>1 By the Purchasing Director</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Issue list of &quot;purchasing orders&quot;</td>
<td>NVA</td>
<td>Purch</td>
<td></td>
<td>2nd Dec.16:05h</td>
<td>20 min</td>
<td>5 min</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>Send list of &quot;purchasing orders&quot; to Pharmacy Department</td>
<td>NVA</td>
<td>Purch</td>
<td>229mt</td>
<td>3rd Dec. 10:30h</td>
<td>5 min</td>
<td>2 hours and 30 min</td>
<td>1 Purchasing administrative person</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Authorize &quot;purchasing orders&quot;</td>
<td>NVA</td>
<td>Purch</td>
<td>9,5mt</td>
<td>09th Dec 15:30h to 16:45h</td>
<td>1 hour and 4 days and 4 hours</td>
<td>1</td>
<td>By the vice-president Once every 2 weeks</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Send &quot;purchasing orders&quot; to purchasing area</td>
<td>NVA</td>
<td>Purch</td>
<td>13,2mt</td>
<td>9th Dec. 17:00h</td>
<td>15 min</td>
<td>15 min</td>
<td>1 By the Purchasing Director</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Reception, separation and filling of &quot;purchasing orders&quot;</td>
<td>NVA</td>
<td>Purch</td>
<td></td>
<td>10th Dec 9:00h (90min.)</td>
<td>1 hour and 30 min</td>
<td>0 min</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Send copy of &quot;purchasing orders&quot; to archives</td>
<td>NVA</td>
<td>Purch</td>
<td>1mt</td>
<td>10th Dec. 10:30h</td>
<td>2 min</td>
<td>0 min</td>
<td>1 Purchasing administrative person</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Send fax to supplier with &quot;purchasing order&quot;</td>
<td>VA</td>
<td>Purch</td>
<td>4,9mt</td>
<td>10th Dec 11:10h (34s)</td>
<td>0,5 min</td>
<td>40 min</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Send &quot;sent purchasing order&quot; to Pharmacy Department</td>
<td>NVA</td>
<td>Purch</td>
<td>229mt</td>
<td>10th Dec 15:00h</td>
<td>5 min</td>
<td>2 hours and 45 min</td>
<td>1 Pharmacy administrative person</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Receive and register &quot;sent purchasing order&quot;</td>
<td>NVA</td>
<td>Pharm</td>
<td></td>
<td>11th Dec 9:30h</td>
<td>5 min</td>
<td>2 hour and 30 min</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Waiting for product reception</td>
<td>NVA</td>
<td></td>
<td></td>
<td>11th Dec (during the morning)</td>
<td>1 day and 4 hours</td>
<td>0 min</td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>Reception of product by the Pharmacy Department</td>
<td>VA</td>
<td>Pharm</td>
<td>5mt</td>
<td>11th Dec 14:30h</td>
<td>10 min</td>
<td>0 min</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Compare &quot;sent purchasing order&quot; and bill</td>
<td>NVA</td>
<td>Pharm</td>
<td>10mt</td>
<td>11th Dec 14:40</td>
<td>20 min</td>
<td>0 min</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>Introduce &quot;sent purchasing order&quot; into information system</td>
<td>NVA</td>
<td>Pharm</td>
<td></td>
<td>15th Dec</td>
<td>30 min</td>
<td>1 day and 4 hours</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>Send bill to Purchasing Department</td>
<td>NVA</td>
<td>Pharm</td>
<td>229mt</td>
<td>18th Dec 14:30h</td>
<td>5 min</td>
<td>3 days and 2 hours</td>
<td>1 Pharmacy administrative person</td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>Separate bill and duplicates</td>
<td>NVA</td>
<td>Purch</td>
<td></td>
<td>4nd Jan</td>
<td>2 min</td>
<td>8 days</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>Introduce bill data into information system</td>
<td>NVA</td>
<td>Purch</td>
<td></td>
<td>6th Jan</td>
<td>10 min</td>
<td>2 days</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>Send bill to Accounting Department</td>
<td>NVA</td>
<td>Purch</td>
<td>283mt</td>
<td>7th Jan</td>
<td>5 min</td>
<td>1 day</td>
<td>1 Purchasing administrative person</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td>1266,7 mt</td>
<td>12 days + 1 hours + 3,5 min</td>
<td>26 days + 7 hours + 53 min</td>
<td>34</td>
<td></td>
</tr>
</tbody>
</table>

Table 1 - Process Activity Mapping for product Tenecteplase 10000 UI AMP
In those cases in which the “purchasing request” identifies more than one supplier for the same product, all of them are contacted by the Purchasing Department by phone to check on product availability, price (sometimes the price can be lower than the one announced on the Central Administration website), and if there is possibility to use unitary doses of product. In these cases the “purchasing request” physically returns to the Pharmaceutical Department to allow the Head of that department to choose the supplier. It is possible to purchase partially from several suppliers. Then the document is one again sent to the Purchasing Department. Although the described situation is possible it did not occur during the process mapping period.

Some of the suppliers have local representatives. When it happens, that information is added to the “purchasing request” at the Purchasing Department.

When all previous activities are fulfilled, the Purchasing Department employee adjusts the “purchasing request” with additional data on the supplier (activity 8) – location, fax number, unitary dose, etc.. Once these activities are concluded, the document waits for its data to be introduction on the Purchasing Department information system.

The “purchasing request” information is then introduced into the Purchasing Department information system (activity 9). The output is a printed “purchasing order”.

Once printed, the “purchasing order” is sent to the head of the Purchasing Department who confirms it (activity 10) after analysing the data available. Afterwards the head of the department leaves it at the meeting room (activity 11) where it waits for approval by the vice-president of the hospital (activity 14). The vice-president passes by once every two weeks to access these orders. In case of emergency situations, the “purchasing orders” are sent directly to his office for approval.

While the “purchasing orders” wait for approval, the purchasing employee prints copies (activity 12) which are sent to the Pharmaceutical Department (activity 13). These activities are performed so that in case of stock out the pharmacy will send an urgent order directly to the supplier according to the information on the formal order.

Once authorised by the vice-president, the document is left on the purchasing employee desk (activity 15). She will then separate the sheets (activity 16), each to different purposes. Two copies are filed (activity 17), one is delivered to the Pharmaceutical Department employee (activity 19) on one of her visits to the Purchasing Department, and the other one is sent by fax to the supplier (activity 18) and filed with the fax delivery confirmation.

The process was mapped during November. It is policy of the hospital that all orders must be placed no later than the 12th of December. Therefore all orders were announced as very urgent to the suppliers, which signifies that the quantity ordered should be delivered all at once.

During other periods of the year the supplier, although received the order by fax, has to wait for phone confirmation before shipping the products. The phone call will inform the supplier on the partial deliveries that are to be sent.
At the Pharmaceutical Department, once the “sent purchasing order” is received, it is registered and filed (activity 20). From this moment on the Pharmacy Department waits for product reception (activity 21).

Once the products arrive they are checked in terms of quantity, reference, expiry date, and size of boxes and then are stored (activity 22). The bill is checked by the administrative employee in terms of price and taxes, and then stamped (activity 23). Information is also introduced into the Pharmacy Department information system (which is independent from the purchasing information system) (activity 24).

Once information is on the Pharmacy information system the bills are sent to the Purchasing Department (activity 25). Here the bill duplicates are separated (activity 26) and information introduced into the Purchasing Department information system (activity 27). Finally, an employee from the Purchasing Department sends it to the Accounting Department (activity 28).

From the mapping analysis it is possible to identify several types of waste that repeatedly emerge. Taking into account the waste classification in the services area shown in Hines and Martins (2005), the main wastes identified are as follows:

- Unnecessary movement: employees keep moving between departments, carrying documents;
- Duplication: data is duplicated in independent information systems inside the same hospital; information from the “purchasing request” has to be corrected and adjusted at the Purchasing Department;
- Unclear communication: official information in the Central Administration website has to be confirmed;
- Delay: “purchasing orders” are sent to the vice-president for approval just for formality purposes as he does not evaluate any related information, just signs; documents wait several hours, sometimes days, at desks before they are processed.

The overall process, although producing the results in terms of product reception, takes too long to achieve that purpose and requires intervention of many employees. This leads to increased costs without any value being added for the customer.

The full process requires more than 40 working days to be fulfilled (can go up to 46 if the vice-president of the hospital takes two weeks to authorise the “purchasing request”). Of these, only about 11 are in fact useful time. Of these 11 days, most of the time spent involves non-value adding activities. The inventory level of the hospital has to be increased to overcome such a long lead time. Therefore average inventory and space needed are higher, involving higher costs, especially if the products involve short expiry dates. These extra costs from the present process forces the hospital to reduce the value it provides for the customer instead of increasing it.

The initial problem of the pharmacy information system requiring 7 days to produce information so that the shortage list may be computed is but the waste iceberg tip. The software is out-dated and there is no other system to control entry or exit of products but manual control. In fact, although the hospital purchased barcode readers and the appropriate software several years ago, these are still in their original boxes.
There might be several suppliers for the same product. As suppliers know that they will be consulted whenever orders are to be placed, they try to get the order by offering a reduced price for the product. Although this practice leads to reduced costs for the hospitals, negotiation with the Central Administration should be final and the minimum cost should be announced in advance. This way parallel business, if there are any, would also be avoided.

During the mapping procedure it was found that products are not purchased individually but several at the same time, regardless its quantity, criticality, or classification according to the Pareto Rule. All the findings identified in the mapped process for a specific product also apply to many other products.

It is also relevant to highlight that for urgent request it is often used parallel processes to speed the system and assure that the patient receives the products as soon as possible. It involves a high level of trusts between the hospital and the supplier. The products are directly asked for by phone and later confirmed by fax to the supplier and immediately sent from the main land to the island. Only then the internal formal process is initiated (a phantom purchasing process) so that the supplier may be paid for the products.

THE PROPOSALS

Taking into consideration a lean approach, the waste levels, and the consequences of that waste on the value provided, a new tentative process was developed. Information technology is one of the main problems in the hospital process. Its improvement is one of the baseline suggestions the proposals assume. It is also assumed that, in the future, information available in the Central Administration website is correct.

The internal physical and informational flows are confusing and their simplification is also a goal of the proposals.

It is not a goal of the proposals to remove decision power to the hospital’s vice-president. Instead, delegation of power is assumed so that the process may be faster and lead to a smaller inventory levels, reduced costs for the hospital, and more value to the customer.

It is not possible to overcome the fact that the hospital is located in an island in the middle of the Atlantic Ocean. Products will always have to be shipped from the main land. Nonetheless, if better forecasts are produced and more information concerning the demand level is shared with suppliers those with local representatives may receive preference due to their ability to provide shorter lead times. In fact, it is not only the cost that dictated the choice of the supplier, lead time is also a relevant criteria.

First proposal

Taking the previous topics into consideration an initial proposal was developed and is as shown in Table 2.

According to data from previous years and additional adjustments from present information, a forecast has to be produced. According to this data and the inventory
level an information system (a new one, for instance an ERP system) would produce the shortage list and suggest the order for each product (activity 1).

It is assumed that the information system would be linked to the Central Administration website and would be able to identify the proposed supplier. Nonetheless, when several suppliers are available the Purchasing Department would have to check for specific requirements, in needed (activity 2).

<table>
<thead>
<tr>
<th>N.</th>
<th>Activities</th>
<th>Type of activity</th>
<th>Area</th>
<th>Distance</th>
<th>Time</th>
<th>N. persons involved</th>
<th>Obs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Determine shortages and order size</td>
<td>VA Pharm</td>
<td>-</td>
<td>20 min</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Consult Central Administration website</td>
<td>NVA Pharm</td>
<td>2 mt</td>
<td>10 min</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Produce &quot;purchasing request&quot; on the information system</td>
<td>NVA Pharm</td>
<td>2 mt</td>
<td>5 min</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Send &quot;purchasing request&quot; to Purchasing Department</td>
<td>NVA Pharm</td>
<td>-</td>
<td>0.5 min</td>
<td>1</td>
<td>Using E-doclink</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Reception of &quot;purchasing request&quot; and issue &quot;purchasing order&quot;</td>
<td>NVA Purch</td>
<td>-</td>
<td>5 min</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Send &quot;purchasing order&quot; to Purchasing Director for approval</td>
<td>NVA Purch</td>
<td>-</td>
<td>0.5 min</td>
<td>1</td>
<td>Using E-doclink</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Approval of &quot;purchasing order&quot; and send it to purchasing areas</td>
<td>NVA Purch</td>
<td>-</td>
<td>5 min</td>
<td>1</td>
<td>Using E-doclink</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Send &quot;purchasing order&quot; to supplier</td>
<td>VA Purch</td>
<td>-</td>
<td>0.5 min</td>
<td>1</td>
<td>By e-mail</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Wait for product reception</td>
<td>NVA</td>
<td>-</td>
<td>1 day and 4 hours</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Reception of product by the Pharmacy Department</td>
<td>VA Pharm</td>
<td>-</td>
<td>10 min</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Compare &quot;sent purchasing order&quot; and bill</td>
<td>NVA Pharm</td>
<td>-</td>
<td>20 min</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Introduce &quot;sent purchasing order&quot; into information system</td>
<td>NVA Pharm</td>
<td>-</td>
<td>10 min</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>System informs purchasing department</td>
<td></td>
<td></td>
<td>Using E-doclink</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Send bill to Accounting Department</td>
<td>NVA Pharm</td>
<td>412 mt</td>
<td>10 min</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td>416 mt</td>
<td>1 day + 5 hours + 36.5 min</td>
<td>14</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2 – Mapping of the first proposal to improve the process

Once data was reunited, the head of the Pharmaceutical Department should produce/ correct/ accept the “purchasing request” on the information system (activity 3). Once concluded, this information would immediately be sent to the Purchasing Department through the information system, even if only the present e-doclink was in use (activity
4). E-doclink is a communication system that is already implemented and in use at the hospital. It works as an internal message exchange system.

At the Purchasing Department the “purchasing order” would then be received and additional information of logistical nature would be added (activity 5). As the information about the suppliers should be already available in the system, this activity would require only a few minutes. A “purchasing order” would be issued and sent to the head of the Purchasing Department (activity 6) through the e-doclink.

Assuming that the head of the Purchasing Department would have power to send orders directly to the suppliers (and this is a common practice in several hospitals for orders up to a certain limit of cost), she would be able to evaluate the order and confirm it if correct (activity 7). Then it would be sent it back to the department by e-doclink.

Once received by the appropriate Purchasing Department employee, the “confirmed purchasing order” would be send to the supplier by e-mail (activity 8). Fax could also be used.

From this moment on the hospital would be waiting for the product (activity 9). As no other changes are considered but the ones on the hospital process, it is assumed that the delivery time remains the same.

Once the product is received it has to be checked for quantity, reference, expiry date, and size of boxes (activity 10). If bar codes are used, and that is available from most suppliers, the technology already available at the hospital could be used. No additional costs would be required and although the time consumed in the activity could be the same, accuracy of the activity would improve.

The “sent purchasing order” would then have to be compared with the bill to check for any discrepancies (activity 11). Information concerning the products received would have to be introduced into the information system (or a simple confirmation of the information already available with eventual adjustments if needed) (activity 12)

Information concerning the receptions of the product would automatically and immediately be sent to the Purchasing Department through the information system (activity 13).

Finally, the bill would have to be physically sent to the Accounting Department (activity 14).

Comparing the present process and this proposal some differences are immediately identified:

- The number of activities was reduced by half;
- The number of times employees have to touch the process has been reduced from 34 to only 14 (reduction of 59%);
- The total distance to be physically covered is reduced from 1266.7 meters to 416 meters, which represents a saving of 67% of the distance;
- The total useful time required was reduced from 10 days, 5 hours and 3.5 minutes to only 1 day, 5 hours and 36.5 minutes. This represents a reduction of 86% of the useful time;
If only the activities up to waiting for the reception of the products are considered, saving are of 99.5% on the useful time.

It should also be highlighted that of the non-value added activities involved in this proposal, almost all of them are support activities and not pure waste as in the current process described in Table 1.

It would also be interesting if instead of continuous orders being placed throughout the year, a single order would be placed on each supplier per year and the deliveries would be phased according to a pre-defined schedule. This would also require the possibility to make delivery adjustments (both in terms of dates or quantity) if needed.

Second proposal

This second proposal was developed according to a more radical approach. This proposal assumes a close relationship between the hospital and its several suppliers on a basis of a Vendor Managed Inventory (VMI) system. This would require that a continuous share of information on inventory levels, consumption levels, and forecasts from the hospital to its suppliers so that it would be the supplier to manage the inventory level within pre-defined inventory levels (minimum and maximum) and logistical service levels, delivering whenever it considered needed (for further detail on VMI see, for instance, Harrison and van Hoek (2011)).

In practice, this solution would allow the hospital to focus on its main goal, which is to supply healthcare services, and leave to the suppliers the management of the inventory.

Both entities (hospital and suppliers) would benefit (reduction in costs and improved service levels are the most common benefits of this arrangement) from this information sharing.

The hospital would receive an improved service level from the suppliers (increased number of on-time deliveries) and a reduced number of stock outs. This would reduce uncertainty and permit a lower investment in inventory. For the suppliers, the benefit would come from the fact that they would continuously receive information concerning the level of demand and the inventory level at its customer (the hospital) and would be able to adjust its own purchasing orders accordingly, allowing it to carry less inventory.

The use of VMI would also facilitate suppliers to have local warehouses as the level of demand would be more stable and the customer (hospital) assured.

In this second scenario urgent orders could be issued according to the first proposal. In fact, there will be requests for special or urgent products as the demand level is unstable.

This second proposal would require a purchasing process as described in Table 3.

This proposal assumes that there would be once a year procedure according to the first proposal to establish costs, quantities, and service level. From that point forward the
process from this second proposal would happen whenever needed. In fact, the moment the second proposal process is to begin would be established by the information system, on the supplier, according to the level of inventory.

<table>
<thead>
<tr>
<th>N.</th>
<th>Activities</th>
<th>Type of activity</th>
<th>Area</th>
<th>Distance</th>
<th>Time</th>
<th>N. persons involved</th>
<th>Obs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>System alerts for replacement need</td>
<td>VA Pharm. and supplier</td>
<td>-</td>
<td>-</td>
<td>On the supplier</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Wait for product reception</td>
<td>NVA</td>
<td>-</td>
<td>60 min</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Product reception and storage</td>
<td>VA Pharm</td>
<td>-</td>
<td>15 min</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Send bill/ transport. document to administrative area</td>
<td>NVA Pharm</td>
<td>412 mt</td>
<td>0.5 min</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td></td>
<td><strong>412 mt</strong></td>
<td><strong>75.5 min</strong></td>
<td><strong>2</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3 - Mapping of the second proposal to improve the process

Whenever the level of inventory would reach a pre-defined limit (for instance a reorder point previously defined according to the lead time of that supplier) it would issue an alert on the supplier (and also on the hospital, if desired, to inform the hospital of what to expect). The alert would inform the supplier that it was time to replace the hospital with a specific product (or products) and would also inform about the most appropriate quantity (activity 1).

After transportation (activity 2) the product is received at the hospital. Reception should be controlled by bar code readers so that the information system would immediately register all entered products (activity 3). The bill would then be sent to the administrative area (activity 4).

It would be possible that no bill was issued and only a transportation document would be sent with the products as an arrangement between the hospital and the supplier could establish, for instance, a monthly payment of the level of consumption or deliveries.

Comparing this second proposal with the present situation, some improvements are to be emphasised:

- Only once a year the purchasing process from the first proposal would take place per product (a process with 14 activities) instead of a continuous process of 28 activities every time the product is required. Replenishment of the inventory level would require a 4 step process for the hospital and almost no effort. This would represent a reduction of 86% in the number of activities when compared to the present process;
• The number of times employees would have to interfere in the process is reduced from 34 (in the present process) to 2 (in the second proposal), which represents savings of 94%;
• The distance covered inside the hospital during the process is reduced from 1266.7 meters to 412 meters, which represents savings of 67%;
• The total useful time required was reduced from 10 days, 5 hours and 3.5 minutes in the present process to only 75.5 minutes. This represents a reduction of 98.5% of the useful time;
• If only the activities up to waiting for the reception of the products are considered, time saving are infinite;
• If only the activities after the arrival of the product are considered, savings are from 82 minutes in the present situation to 15.5 minutes in the continuous reception, which represents saving of 81% of the useful time required.

CONCLUSIONS

This research showed that it is possible to apply the main concepts of lean management in more unstable healthcare processes, even though the level of uncertainty in the specific case study is higher than usual in lean processes. This way it is possible to affirmatively answer to RQ1.

The present purchasing process was mapped on the Hospital do Santo Espírito and the proposals show a reduction in terms of useful time of 98.5%. It was not possible to analyse the direct impact in terms of cost, but with shorter purchasing processes the average inventory level has to be reduced. This way it is possible to affirmatively to RQ2.

It was not possible to implement the proposals, but these are based on assumptions that are reasonable and their practicality reachable. This way the purpose of this research is considered as fulfilled.

As this research focuses a single case study the findings cannot be generalised (Yin, 2003). Nonetheless, many other Portuguese hospitals use similar purchasing processes that might be improved if some of the findings in the present research would be adjusted to their specific reality.

This way, the development of an overall purchasing model that could be used as a basis for every hospital and then receive minor adjustments to be able to fulfil specific requirements is set here as a topic for further research.

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