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An innovative procedure for introducing the lean concept into the internal drug supply chain of a hospital

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Abstract

Purpose – In a hospital, the management of different materials (i.e. waste, drugs, equipment, etc.) is fundamental from an economical point of view and also when considering its impact on patient treatment. The purpose of this paper is to introduce by an innovative approach lean principles in the management of this supply chain.

Design/methodology/approach – After the contextualization of the importance of the drug management in hospitals, authors analyze the literature in particular discussing the points of weakness. They propose an innovative methodology to implement a lean principle in this particular supply chain. After a general discussion authors discuss the application of the proposed methodology in the largest Italian hospital, the Policlinico Sant'Orsola – Malpighi in Bologna.

Findings – The results are very encouraging, confirm the value of the methods and motivate the authors to do further research. The proposed methodology takes into account both a technical approach and the real behavior of a hospital including logistics knowledge and motivation for material management in ward personnel. Real results are interesting both in term of economic impact and in term of effect on patient care.

Originality/value – Maximizing patient care is the mission of the healthcare system; however, poor management of drugs and materials can have serious effects on the quality of service. In the last years, several excellent technological solutions have been developed, but often their application in the field was limited and ineffective due to the gap in knowledge and commitment required and available in the ward's personnel. The new methodology developed is focused to solve this gap and was tested in an important case study.

Keywords Case study, Lean healthcare, Drug supply chain, Material management system

Paper type Research paper

1. Introduction

Despite the existence of well-documented evidence on the benefits of introducing supply chain management (SCM) practices to gain significant competitive advantage and cost reductions, the healthcare sector has been extremely slow to embrace these practices (McKone-Sweet *et al.*, 2005).

The careful management of material and the flow, equipment and information associated with it becomes a crucial factor to improve both care processes (core activities) and support procedures. Additionally, logistics and supply management have a notable impact on budget (Manzini *et al.*, 2006); some studies (Landry and Philippe, 2004) affirm that 46 percent of the operating budget in the healthcare system is dedicated to logistical activities. Other studies implemented in several hospital in the USA (Lynch *et al.*, 1991) estimate that for each dollar spent on the purchase of hospital supplies, an additional $0.70 is added for logistics.

Maximizing patient care is the mission of the healthcare system; however, poor management of productive areas can have serious effects on the quality of service (Nat Natarajan, 2006).

The hospital is much more than simply a link in the supply chain (Landry and Beaulieu, 2007) and its internal supply chain is highly complex due to assorted and variable characteristics of materials. Therefore, reducing waste and increasing efficiency in this

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complex system is a global challenge, highlighting the need to identify any source of potential improvement and using any methods and technologies to improve healthcare delivery and services. In this scenario, the logistics of drugs play a fundamental role because the associated purchasing and managing expenditures have a high impact on budgets.

Drugs in hospitals are traditionally managed with large stocks. Storage is usually guaranteed both in a central warehouse and, more importantly, in the wards. This is the normal procedure, although it is not justified by the actual need to prevent a depletion of hospital supplies. The internal supply chain of drugs is usually managed by hospital personnel who are not involved in the hospital's cost-conscious environment. In addition, the ward staff often does not use rational methods and techniques for inventory management, but manage based on their skills and experience. This discrepancy generates inefficiency that can directly and indirectly result in low-service quality and extra costs for the healthcare structure. Moreover, the ward warehouses are often not well organized, as the same product can be found in different locations. Incorrect management, therefore, generates an inadequate utilization of space. This situation does not guarantee adequate rotation and utilization of the hospital material, the consequence being that many drugs expire and resources become redundant. Moreover, the traditional organization of the materials in a cupboard and on shelves produces a Last In First Out picking procedure. This is in contrast with the more satisfactory First Expired First Out procedure.

It is possible and necessary that healthcare institutions have processes in place to improve efficiency, allowing them to generate sustainable development, increase the level of service to the patients and minimize the resources used.

Healthcare logistics processes have been investigated to some extent in the literature, including medical supply (Kumar *et al.*, 2008), pharmaceutical supply, patient flow logistics, sample warehousing and transports and bed logistics (Haywood-Farmer, 1988; Faber *et al.*, 2013; Waring and Alexander, 2015; Gobbi and Hsuan, 2015). The literature survey also shows that several logistical healthcare processes have not been explored in the literature. Healthcare logistics should not only be viewed as a means to achieve savings for logistical processes but also as a method for having a more strategic role by supporting the clinical organization in achieving more productive clinical processes (Pinna *et al.*, 2015; Landry and Philippe, 2004).

Despite well-documented evidence of significant competitive advantage and cost reduction resulting from applying method of advanced SCM management, the healthcare system has been extremely reluctant to adopt this practice. Studies have investigated how the logistical activities in a hospital are performed and the opportunity for improving processes to reduce costs by implementing improvement initiatives such as Just-in time (Chunning and Kumar, 2000; Aptel and Pourjalali, 2001; Kumar *et al.*, 2008), innovation processes, lean techniques (Ishijima *et al.*, 2016) and business process reengineering (Rivard-Royer *et al.*, 2002) that seem to be particularly suitable to overcome the weaknesses of the logistics of the hospital drug management process.

Today's business literature is rife with SCM models, theories, and more importantly, case studies of the successful application of SCM principles in a healthcare supply chain. For example, because of the performance achieved by the application of the unit dose system at the "G. Brotzu" Hospital in Cagliari, it is possible to obtain significant organizational changes for physical and information flow management (Pinna *et al.*, 2015). Persona *et al.* (2008) discuss the use of the Kanban technique in Padua's Hospital and at Turin's Hospital, to first minimize possible personnel errors and second to refill drugs and medical supplies for the wards. Additionally, Harrison and Tatsuya (2006) discussed the use of electronic pedigrees, mass serialization and authentication of drugs to combat counterfeit drug problems, while Bertolini (2009) used the new auto-identification technologies (RFID) to trace and track drugs to obtain significant improvement in the visibility and security of the pharmaceutical supply chain (Koh *et al.*, 2003; Fosso Wamba *et al.* 2013; Romero and Lefebvre, 2015). In general prior studies considered single aspect of the supply chain of drug. Many different flows of information and material in a hospital have resulted in a range of clinical staff contributing to the logistics activities associated with the various supplies. So, within a hospital, almost everyone is involved in the supply chain, although few realize it in a systematic and effective manner (Landry and Beaulieu, 2002). Among the professionals involved, the clinical staff often has neither the expertise nor the resources to efficiently manage logistics activities. In addition, when considering nursing personnel, it is important to find methods to ensure that all efforts of clinical staff are focused on patient care. However, many of these employees currently spend a significant amount of their time on logistics tasks (Chow and Heaver, 1994; Rivard-Royer *et al.*, 2002). Additionally, nurses are often interrupted in their work because of supply shortages and other logistics problems (Tucker and Edmondson, 2003).

The hospital, due to the particularities of its internal supply chain, merits greater attention and solutions are needed that address this unique situation.

The benefits that can be generated through sound management of the hospital supply chain are equally unique. Whereas using effective logistics in the industrial and retail sector can lead to reduced costs and increased customer service, efficient logistics in the healthcare sector can yield other substantial gains (Landry and Beaulieu, 2013). Recent developments in the healthcare sector demonstrate the extent to which SCM is gaining the attention of top management. In the healthcare supply chain there are many challenges in the management of drugs: products and medical devices used for procedures can be extremely expensive, demand for the types and amount of material required for treatments can be highly unpredictable due to the diversity in patient characteristics, inventory tracking can be difficult due to the urgency of medical procedures and product expiration and tracking issues caused by a lack of accountability for products managed under a consignment process (Balaji *et al.*, 2010).

Based on the literature and using a theoretical point of view, the methods most commonly used to distribute supplies to hospital wards have changed over time from clinically driven requisition-based systems, exchange carts and periodic automatic replenishment or par level systems to the more recently introduced two-bin system, RFID-enabled two-bin system, weight control bins and user-driven unitary demand capture systems (Landry and Beaulieu, 2013). The order in which the above replenishment systems are presented follows the same sequence as their introduction into the healthcare sector. This evolution came in three waves. In the 1970s, the exchange cart system began to overtake the requisition system in popularity. In the 1980s, the par level system appeared more efficient than the exchange cart system by providing appreciable advantages through reductions in stock and storage space in central stores, as it eliminated the need to manage duplicate mobile supply carts. The third development came at the end of the 1980s, when the two-bin Kanban system was introduced and delivered significant gains over its predecessors. Conversely, in the early 1990s, the USA saw the introduction of automated storage cabinets in nursing units, the first user-driven unitary demand capture system to provide perpetual inventory management. A few years later, in an effort to reduce compliance issues, some vendors introduced RFID transponder technology, thus eliminating the requirement for nursing unit staff to record transactions (Bendavid *et al.*, 2010). In the mid-2000s, a weight control bin solution for general supplies was adapted from the industrial sector and introduced into the US healthcare sector. The mid-2000s also saw the development of an RFID-enabled two-bin replenishment system (DeJohn, 2005; Feibert and Jacobsen, 2015).

Despite the recognized importance of managing the hospital supply chain, tremendous variability exists in the design and management of supply chains/distribution of drugs and previous real-world results were very contrasting and debatable. There has also been limited academic research that assists in the design of a successful implementation of an SCM program or recommends best practices.

The main difficulty therefore lies in defining a standardized procedure for proper drug management, combined with the complexity of being able to motivate and create an appropriate growth path for the ward staff. The ward staff often considers logistics activities to be time consuming and secondary to their core activities.

In the real world there are several excellent systems for drug management, usually due to the presence of particular conditions or individual managers with significant knowledge. However, there lacks a systematic approach that can facilitate the improvement process.

In this context, the authors develop an innovative soft procedure for the introduction of lean concepts into the internal supply chain of drugs in a hospital. This procedure was tested in an important hospital in northern Italy.

The paper is organized as follows: Section 3 discusses the proposed procedure and Section 4 presents the application of the procedure in the case study, discussing opportunities, results and problems. The conclusions and further activities are provided in the last section.

2. Materials and methods

As previously stated, the proposed method emphasizes the importance of the continuous development of operator skills and awareness through a procedure that will accompany them on a technical solution and mental growth path, until they obtain the use of very advanced solutions (i.e. unit dose, RFID technologies, etc.)

The purpose of this section is to clarify the methodology developed to introduce lean concepts into drug management in a hospital system, as summarized in Figure 1.

2.1 Analysis of "as is" points of use

Figure 2 shows the typical drug supply chain of a hospital. First, you must make a distinction between the two channels typically used by the healthcare structure for the supply of drugs; the first uses a central warehouse where drugs are stored, the second, however, supplies the drugs to the points of consumption directly from the suppliers. Usually the two channels are focused on different types of products: ordinary products (often used and inexpensive) and special products (rarely used and often expensive).

Usually the management policies for the two types of products are different: the ordinary products are managed by a central stock at the hospital (stock policy) and the special products (i.e. prosthesis, dilatators, etc.) are managed using direct orders to the supplier (material requirement planning policy). The ordinary products usually have a larger economic impact. For this reason the suggested method addresses this category of material.

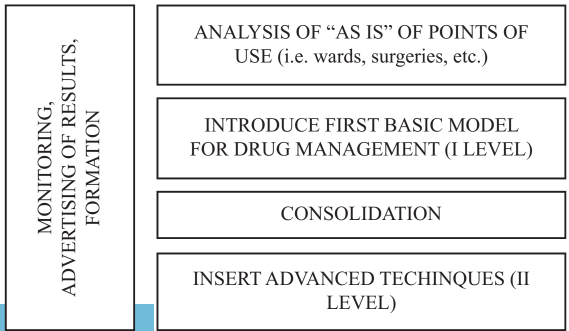

Figure 1.
Framework of the innovative soft procedure

The point of use can be analyzed through several indicators:

(1) General key performance index – KPI analysis:

- total consumption value (€), within a period of time;
- average total stock value (€); and
- average turnover rate, calculated as:

$$\mathrm{TR} = \frac{\text{Total consuption value (€)}}{\text{Total stock value (€)}}.$$

This indicator expresses the number of times stocks are completely renewed in the studied time period. It is an important parameter both because a hospital has to address perishable products and because in this context a low rotation of warehouse stock causes a financial immobilization that threatens the hospital's survival:

(2) Cross analysis stock/consumption (cross matrix).

The Cross Matrix is a tool that allows the products to be split into classes and helps to understand the most appropriate management for each of them. It is based on the Pareto principle, which states that the majority of the effects depend on a limited number of causes. This analysis allows, therefore, a definition of which articles require more attention.

The process for the realization of the matrix is the following: for each article, calculate the relative percentage of its consumption value compared to the total consumption value at the point of use. For a generic product:

$$\text{Relative Frequency}_i\% = \frac{\text{Consumption}_{ith}}{\text{Total Consumption}} \times 100.$$

The relative frequencies computation is performed successfully and the results are ordered in a descending manner. Finally, the cumulated frequencies are calculated. This method enables classification of products into three categories of interest. The first category (Class A) includes all products whose cumulated consumption involves 80 percent of the total amount, the second category (Class B) are between 80 and 95 percent and the third (Class C) are the remaining 5 percent of consumption. The same approach has been used to classify the total stock value (classes: a, b, c).

Eventually, the Cross Matrix was obtained by merging these two classifications.

In particular, the Cross Matrix area can be divided into three parts (see example in Figure 3):

(1) The coherence diagonal is formed by classes Aa, Bb and Cc, which includes products having coherent consumption and stock value.

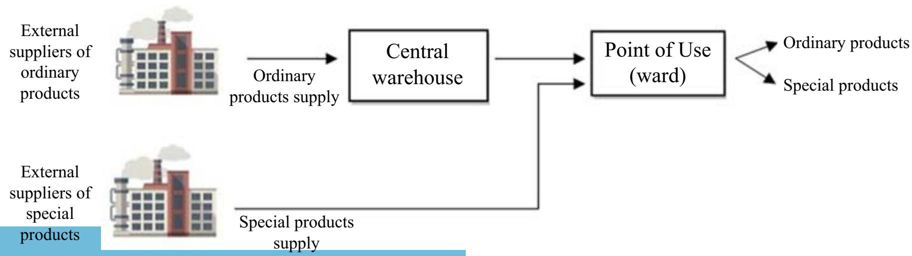

Figure 2.
The drug
supply chain

CONSUMPTION		STOCK a	STOCK b	STOCK c	Total
A	Sum of Consumption (€)	€653.997	€172.225	€150.132	€976.355
	Sum of Stocks (€)	€71.119	€5.106	€110	€76.337
	Number of Items	38	18	7	63
	Sum of Stocks (€) %	50.56%	3.63%	0.08%	54.27%
	Sum of Consumption (€) %	54.18%	14.27%	12.44%	80.89%
	Number of Items %	8.72%	4.13%	1.61%	14.45%
B	Sum of Consumption (€)	€32.631	€92.224	€58.025	€182.880
	Sum of Stocks (€)	€23.734	€8.625	€1.229	€33.589
	Number of Items	14	43	32	89
	Sum of Stocks (€) %	16.87%	6.13%	0.87%	23.88%
	Sum of Consumption (€) %	2.70%	7.64%	4.81%	15.15%
	Number of Items %	3.21%	9.86%	7.34%	20.41%
C	Sum of Consumption (€)	€3.030	€12.179	€32.570	€47.780
	Sum of Stocks (€)	€18.863	€7.571	€4.293	€30.728
	Number of Items	11	48	225	284
	Sum of Stocks (€) %	13.41%	5.38%	3.05%	21.85%
	Sum of Consumption (€) %	0.25%	1.01%	2.70%	3.96%
	Number of Items %	2.52%	11.01%	51.61%	65.14%
TOTAL	Total Sum of Consumption (€)	€689.658	€276.628	€240.727	€1.207.015
	Total Sum of Stocks (€)	€113.716	€21.302	€5.632	€140.654
	Total Number of Items	63	109	264	436
	Sum of Stocks (€) %	80.85%	15.15%	4.01%	100.00%
	Sum of Consumption (€) %	57.14%	22.92%	19.94%	100.00%
	Number of Items %	14.45%	25.00%	60.55%	100.00%

Figure 3.
Cross matrix

(2) The area above the coherence diagonal, including classes Ab, Ac and Bc, shows products whose stock is insufficient to meet the hospital's requirement. The products of these classes have been called "Products at risk of Stock out" and their absence usually results in a decrease in the level of service.

(3) Finally, the area below the diagonal, which is made up of classes Ba, Ca, and Cb, refers to products whose stock value more significantly affects the total warehouse stock compared to how their consumption affects the warehouse consumption value. Due to this, controlling their stock it is necessary to prevent materials from expiring. Products belonging to these classes are known as "Products at risk of obsolescence."

The Cross Matrix defines more clearly the difference between products "at risk of Obsolescence" and "at risk of Stock out." Frequently performing this analysis allows management to monitor the ward's evolution and product transition from one class to another.

2.2 Introducing a basic drug management method

The first step to optimize the ward's stock management consists of involving and developing people, introducing the logic of efficient management and how it is simple and not too far from their traditionally applied methods.

Then, the primary step to optimize stock management consists of making the sanitary staff understand how to manage ward stock reasonably both in term of quantity and operating procedures. One of the most significant problems to be addressed is that healthcare assistants define a ward stock level based on their experience rather than on analytical criteria. In fact, a stock level established by them refers to quantities they want and not to quantities the ward really needs in a certain period of time. Another problem is the operators' poor knowledge and respect of the relevance of the stock management procedures. For these reasons, the authors suggest that initially a very basic method for stock management be introduced.

Among the basic drug management methods are the fixed reorder level model, the economic order quantity and the fixed reordering interval method (Grubbström, 1995). In the case study discussed in Section 4, the authors use the latter.

In practice, the point of use order quantities for each product are variable and depend on the difference between a fixed stock level, known as the objective level and product availability (H) at a specific moment in time. The available stock in a point of use system is the sum of the physical inventory (G) and orders not yet received (OC), deducted from the amount involved (IM):

$$\mathrm{H} = (\mathrm{G} - \mathrm{IM}) + \mathrm{OC}, \quad (1)$$

$$\text{Quantity amount to be ordered } \mathrm{Q} = \mathrm{OL} - \mathrm{H}, \quad (2)$$

$$\text{Objective level } \mathrm{OL} = y \times (\mathrm{RI} + \mathrm{LTs}) + k \times \sigma \times \sqrt{\mathrm{RI} + \mathrm{LTs}}, \quad (3)$$

$$\text{Safety stock } \mathrm{SS} = k \times \sigma \times \sqrt{\mathrm{RI} + \mathrm{LTs}}, \quad (4)$$

where y: daily consumption (average monthly consumption/30); RI: reorder interval, period of time between two consecutive orders; LTs: lead time of supply, period of time between sending the order and the material arriving; k: safety factor, which guarantees a defined level of service; σ: standard deviation of y; y^*: monthly average amount sent from the central warehouse to the ward; σ^*: standard deviation of y^*.

2.3 Consolidation: monitoring, advertising of result and formation

After the first phase of studying the wards, a close partnership was created with the ward's healthcare personnel to introduce the basic method of stock management without too many issues.

To facilitate procurement activities, visual management techniques for materials, widely experienced in the industry, such as labels, project table boards, warehouse paper lists, etc., can be used. These tools, in addition to facilitating integration activities, also allow implementation of a department staff motivational and training plan to reach the required growth path (see case study – Section 3).

2.4 Introduction of advanced techniques

After the stabilization of the previous model and operators' comprehension of the procedures, advanced stock management methods may be introduced. Among the most commonly used methods are clinically driven requisition-based systems, exchange carts and periodic automatic replenishment or par level systems to the more recently introduced two-bin system, RFID-enabled two-bin system, weight control bins and user-driven unitary demand capture systems.

It is important to reiterate that without having reached the proper consolidation of the first level procedure, each introduction of tools, models or very sophisticated equipment can introduce risk, even creating additional inefficiencies in material handling.

3. Case study and results

The proposed method has been applied at the Policlinico S. Orsola – Malpighi, a major and highly complex hospital in Bologna (northern Italy). With its 1,535 beds divided into 90 wards, it is the largest hospital in Italy.

The Policlinico Sant'Orsola – Malpighi uses the two previously discussed channels (central stock for ordinary materials called stock materials and the direct supplier-ward channel for special materials called transit materials). We will focus our attention on the former.

Procurement activities in the wards are triggered by the warehouse receipt of replenishment requests. There are several physical paths to release an order (e.g. online, e-mail, phone call, etc.) and therefore, there are different types of requests, mainly programmed with a one day of supplying LT and urgent with three hours of LT.

The test of the new proposed methodology was conducted initially in a surgical unit because it was the most complex, followed by the other types of wards.

3.1 Analysis of points of use

The application of the new procedure began in 2014 with the study of the physical and information flow of drugs and other materials based on the data collected from available corporate databases.

For stock material, every surgical unit has a local stock of materials. The ward's staff is unwilling to use official procedures for the management of materials (drugs) because they are considered too laborious and time consuming. This approach results in very ineffective management performance of the system in term of the stock level, obsolescence of materials and continuous day-to-day operations problems.

The following sections will show the application of the procedure in a department that for reasons of confidentiality will be called "surgical unit y." Furthermore, the analysis presented focuses on the stock material flow.

Surgical unit Y. Surgical unit y uses local areas as warehouses, each dedicated to different medical product family. This ward can use daily supplies and has personnel fully dedicated to materials management.

Due to the lack of data, physical inventories were performed and compared with the consumption data for different time intervals.

Considering the suggested approach (par. 3.1) and 2013 and 2014 consumption data, the cross matrix was build based on 436 items (Figure 3).

As previously explained, the classes below the diagonal are products at risk of stock out or products with high inventory and low average consumption for which the high immobilization of resources is not justified.

Furthermore, these articles have a high probability of reaching their expiration date. In this analysis, 73 products have had an annual consumption of €47,840; however, they present a stock amount of €50,168. This means that the material has a very low turnover rate, allowing items to be in the warehouse for one year. Special attention is given to these articles, where the stock level is extremely oversized and therefore can incur a significant reduction.

The classes above the diagonal are composed of items that present the reverse situation, thus risking a stock out situation. As the matrix show, the annual consumption of these classes amounted to €380,382 with a stock value of €6,445. Consequently, the coverage time is 3.72 days for these complex and critical safety items.

The above discussed analyses were applied several times, considering different time intervals, and the results were consistent and similar.

3.2 Introducing the basic model

Among the basic methods available, the fixed RI model is quite appropriate to the ward's situation due to their high difficulties in continuously monitoring the stock level of the materials (no IT automatic solutions are applied). Therefore, the fixed time interval method was introduced by first defining the objective level for each item.

For each product the daily demand and the relative standard deviation were calculated. The parameters used in the application of the model are the following:

- the supplying LTs was established at 1.5 days because the central warehouse delivers requested products the morning following the order;
- the RI was set to 1 day for drugs and surgical materials and 3.5 days for the remainder of the products present in a ward; and
- the safety factor (k) was set to 2 to guarantee a 97.77 percent service level.

After all of the required data and parameters were defined, the objective level OL and safety stocks SS were calculated for each product using Equations (3) and (4).

The new objective level was defined for a set of 399 different items, and a pilot test was developed. In this phase the levels were fine-tuned by considering the suggestions of the ward personnel.

Table I summarizes the initial data of the testing phase.

This testing phase is also important to introduce the new approach to the personnel.

The introduction of the basic model of stock management is facilitated by the implementation of other activities, such as the introduction of support tools, training and publicizing the results.

To facilitate the operation of replenishing each product, it has been given a label with the item code, description and the fixed objective level (Figure 4).

To facilitate periodic checking of the stock levels and to ensure that they were as accurate as possible, paper lists sorted by warehouse and geo-reference were developed. This system can be easy developed using a PDA or tablet.

As previously described, the effective application of the new method requires a commitment by ward personnel and training focused on the material logistics issues.

For this reason, an individual training plan was developed as part of a larger training project for the ward staff. To increase their commitment, the results were continually advertised on the project table board shown in Figure 5.

Items inserted into testing phase	399
Consumption items being tested (year 2013)	€1.207.016
Stock at the beginning of the testing phase	€145.837
Sum of objective level values (OLi)	€78.000

Table I. Summary of data at the beginning of pilot test

Figure 4. Examples of labels introduced in the ward

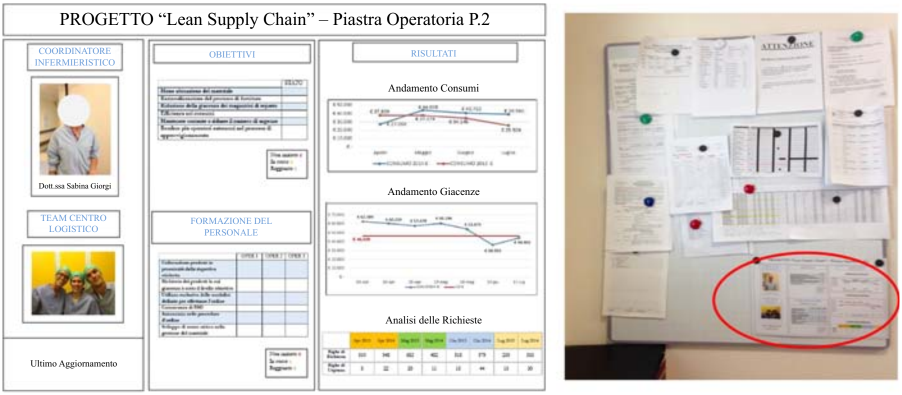

Figure 5.
Project table board

The project table contains the results in terms of ward stock material consumption, stock on hand and skills developed by the operators.

Additionally, a basic requirement for the correct application of the proposed method is the appropriate organization of material stores to avoid duplicate locations of materials, hidden products and/or products not appropriately labeled. Often the material warehouses are not correctly designed, the equipment is not appropriate to the materials and the management is not correct (Plate 1).

For this reason some activities, in collaboration with the Nursing Coordinator, led to a reorganization of the local stores (Plates 1 and 2).

Plate 1.
Local warehouses before pilot project

Plate 2.
Local warehouses after pilot project

This reorganization of the warehouses facilitates the application of the new reorder mode and creates other significant benefits such as:

- space optimization (reduction of space dedicated to material stock);
- time reduction for the material handling process (check of inventory level, place in stock, picking and procurement); and
- immediate reduction of the average level of material inventory.

3.3 Results

The basic procedure presented in Section 4 has been applied in pilot wards representative of the different points of use in the studied hospital. The main impacts of the application of the proposed procedure can be discussed by analyzing the trends of the stock in the ward and the consumption and service level in terms of material not delivered to the wards in time by the central warehouse. Additionally, some results will be reported in terms of storage and consumption of different points of consumption. These levels have been achieved without any degradation of the service level (monitored by the number of urgent requests by the ward) (Figure 6).

Ward level of stock of material. Local stock level of material at the start of the project: €298,198.

Optimum stock level according to the proposed (basic – I level) model: €146,246.

Stock level reached approximately €154,000 (Figure 7).

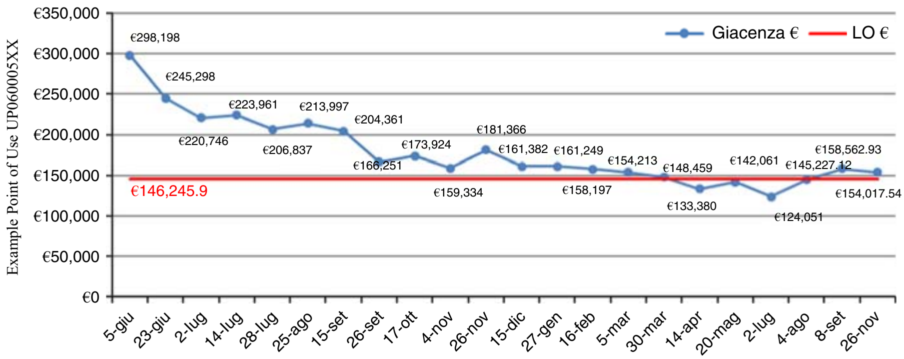

Figure 6.
Trend of ward local stock level of material (red OL level)

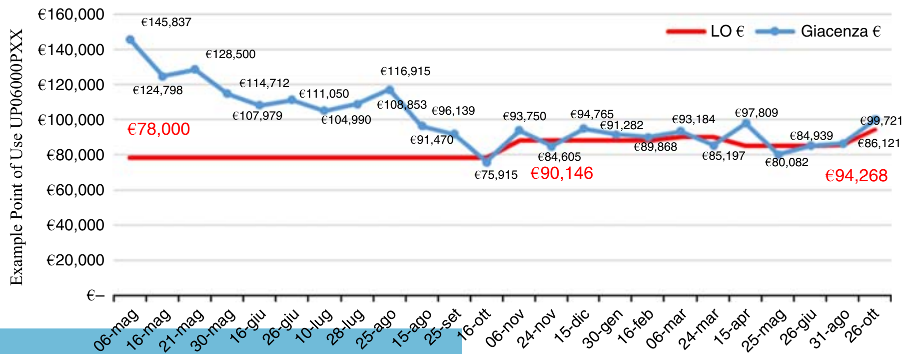

Figure 7.
Trend of ward local stock level of material

Local stock level of material at the start of the project: €145,837.

Optimum stock level according to the proposed (basic – I level) model: €94,268.

Stock level reached approximately €94,000.

During the consolidation phase, revisions to the value of some objective levels were necessary to adapt to the ward's organizational changes. Considering all of the wards engaged in the project with at least thee months of work with the new system, the average reduction in local stocks is 36.9 percent. This result was gained without changes in the stock level in the central warehouse. The inventory reduction in addition generates improvements in the material process management within the wards. In particular:

- reducing the time required for the order release;
- reducing the time required for the material handling; and
- reducing the level of expired material in the local warehouses.

A decrease in inventory also allows us to investigate the criticality of the process.

Ward consumption of material. As seen in both cases shown, the reduction in consumption has a maximum value at the beginning of the project indicating the tendency of the points of use to use accumulated stock and then stabilizes at values lower than those before the application of the proposed procedure.

Figure 8 shows the trends of material consumption of a ward under the new procedure. An effective management of drugs produces a reduction of expired material, a better use of different packages and an effective sharing of expensive materials by different points of use.

The average reduction is about 24.1 percent. In general, considering all the experimental evidences the reduction of consumption ranges from 8.3 to 25.3 percent.

Service level. As a confirmation of the goodness of the proposed procedure, the incidence of urgent ward requests has been analyzed. As shown in Table I, there have not been substantial changes in the points of use under the application.

Example of incidence of urgent requests issued by Points of Use UP06000PXX and UP060005XX (Table II).

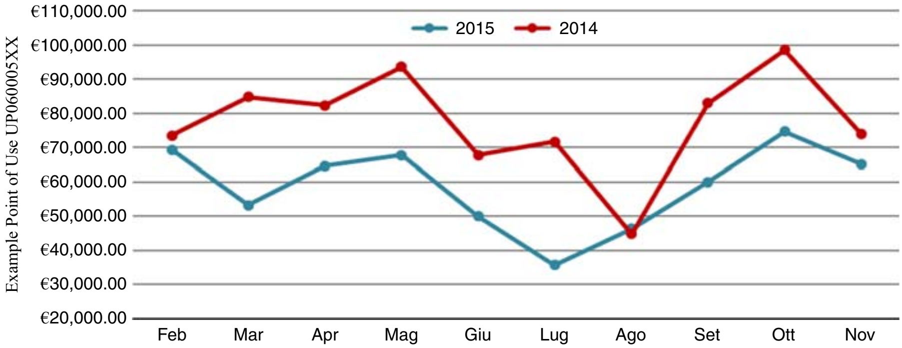

Figure 8.
Trend of ward consumption level of material, before and after the project

Table II.
Service level trends

	April–December 2013 (%)	April–December 2014 (%)	January–November 2014 (%)	January–November 2015 (%)
UP06000PXX	0.0012	0.0036	0.0031	0.0028
UP060005XX	0.40	0.25	0.69	0.304

During the test of the new proposed method, resistance to change by the ward's staff has been the main difficulty. Therefore, the first condition for success of reengineering processes is commitment by managers and ward personnel.

When the process is in the consolidation phase, the authors are planning and designing the second-level solutions, such as surgery kit, Kanban systems and double bin, intelligent cabinets. However, these advanced solutions require careful planning and, if possible, a simulation of their impact. They require significant investments both in term of financial resources and personnel knowledge. A problem in material supply can have very serious consequences.

4. Conclusions

In a hospital the management of different materials (i.e. waste, drugs, equipment, etc.) is fundamental from an economical point of view and also when considering its impact on patient treatment.

In the last year, several excellent technological solutions have been developed, but often their application in the real-world was limited and ineffective due to the gap in knowledge and commitment required and available in the ward's personnel. In this paper, the authors discuss a soft procedure to introduce the modern lean concept in the supply chain of drugs, while considering real behavior.

This soft procedure is based on two phases. The first phase focused on the analysis of the initial situation and on the introduction of basic material management models. The main goal is to have the ward's personnel increase their knowledge so they can take advantage of all the benefits that the advanced methodology and solutions provide. The second phase is based on the introduction of a level II modern solution of material management (i.e. Kanban and dual-bins methods, RFID solution, etc.).

The authors test the proposed procedures for stock materials in several wards, in particular the surgical units of the Policlinico Sant'Orsola – Malpighi in Bologna. After the application of the first phase, the results are very encouraging; in a group of several surgical units the decrease of the stock coverage in local warehouses was approximately 35 percent and the decrease of the consumption overage was approximately 15 percent without negative impacts on the service level and levels of stock in the central warehouse. The real application confirms that the fundamental rule of a soft introduction is to permit the ward personnel to increase their knowledge about logistics methods and to develop the necessary commitment and satisfaction. In conclusion, the proposed procedure appears very interesting, therefore the authors will be focused on its development and calibration, in particular addressing the test of the second-level methodologies in the field and applying the complete approach to special materials directly supplied to the ward by the inbound market.

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Further reading

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