Intelligent Health Management System – an Italian project to streamline stock management in health facilities

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Abstract

Although the application of industrial stock management techniques to medical supplies is suggested by many studies (Griffin, Scherrer, & Swann, 2006), the great majority of health facilities do not pay the due attention to stock management. The aim of this paper is to present benefits achievable with a proper management of health materials by simulating aforementioned techniques over real data from an Italian hospital. Key benefits are stock reduction and then lower costs for working capital, lower risk of expiration or obsolescence and finally a higher awareness of the warehouse resulting in clinical risk reduction and improved orders management. Those advantages are even more notable in this period because of the financial crisis and the need to streamline stock management while maintaining a very high service level, which is a priority for healthcare services.

Keywords

Health materials, inventory control, clinical risk, stock management

1. Introduction

The aim of the project presented in this paper is to develop a model for centralized management of health materials, intended for hospitals, pharmacies, public health districts and drug manufacturers. In particular the goal is to reduce the time of response (“quick response”) of the logistic system in making available the required material for purposes directly or indirectly related to the service user. Stock management techniques are divided into two main categories: systems based on forecasts (MRP – Material Requirements Planning) and systems based on maintaining an adequate level of stock. Even if in literature there are some attempts to apply MRP system to health facilities (Iannone, Pepe, & Riemma, An MRP-based Architecture to Plan Resources and to Manage Waiting Queue in Hospital Systems, 2009), the complexity in obtaining affordable forecasts (Fruggiero, Iannone, Martino, Miranda, & Riemma, 2012) and the traditional issues of this systems (Bregni, D’Avino, De Simone, & Schiraldi, 2013) (D’Avino, De Simone, & Schiraldi, 2013), limit the spread of MRP in real cases. The
proposed solution is based on the use of the "virtual warehouse", that is the centralized accessibility to information related to materials and on the stock sizing with the “virtual safety stock” technique. Safety stock, namely the technique based on keeping materials in excess with respect to the estimated consumption, is the only solution to ensure the customer service level in conditions of uncertainty. Therefore this technique is currently used in any system where you have to ensure the availability of specific materials to enable the delivery of a service. In this sense, in all health organizations there is a safety stock of materials, more or less critical, in order to ensure their availability and then prompt assistance for patients: the urgency peculiarity that characterize health assistance services entails in fact the use of a safety stock. At the same time, these same characteristics make complex an a priori evaluation of performance reachable within the hospital supply chain (Iannone, Miranda, & Riemma, Supply chain distributed simulation: an efficient architecture for multi-model synchronization, 2007). Unfortunately, in almost all of these organizations, because of the low level of knowledge of their organizational processes and logistics (Iannone, Lambiase, Miranda, Riemma, & Sarno, 2013), the aforesaid safety stock is carried out roughly (and consequently always in excess of the actual needs), or even without awareness (i.e. without distinguish between storage for expected consumption and safety stock). The consequence is that at the same time in some organization there are very high wastage in terms of overstock materials (exceeding their expiration date or physically deteriorated) while in others there are shortcomings of the same types of materials (sold out for sudden surges of consumption). Centralized management of a "virtual warehouse" with the "virtual safety stock" technique is proposed in order to overcome this problem. The material management framework, that is the goal of this work, is intended to collect operational information related to the storage level of materials within tracked organizations in order to determine:
- replenishment / refurbishment needs from suppliers;
- opportunities for inter-organization material transfers;
- the availability of virtual stocks of materials, namely the ability to reallocate materials between organizations, based on transfer times, by exploiting the properties of the virtual safety stock.

2. National and international context

Healthcare industry is recently experiencing a deep structural and organizational change bringing the patient at the center of the process. At the same time, the evolution of information technologies has become more and more insistent and pervasive, moving from isolated applications to the exchange of structured messages and then to standard integrated information systems in "virtual organizations". It follows a new paradigm on healthcare Information and Communication Technology (ICT) based on the sharing of structured information between health care workers and on the integration of clinical, organizational and administrative information (Iannone, Miranda, Riemma, & Sarno, Proposal of a conceptual framework to optimise drug management in healthcare sector, 2011). In this scenario, the World Health Organization recognizes that the growth of health expenditures is strongly influenced by the waste of resources. For example in Italy the average incidence of drugs on the National Health Service is about 6% (European Commission, 2008). Several studies have evaluated the
efficiency of healthcare processes and its redesign based on typical methods of industrial organization (Griffin, Scherrer, & Swann, 2006). The literature is full of contributions on the applicability of industrial logistic methodologies in the health care industry with the aim of improving quality and efficiency (Jamal, McKenzie, & Clark, 2009) (Fruggiero, Iannone, & Riemma, 2011) or providing an overview of actual case studies (Mazzocato, Savage, Brommels, Aronsson, & Thor, 2010) (Pokinska, 2010). However, in the international literature there are not significant studies concerning the development of models and methodologies to support the design of a hospital logistic system. The few attempts in this direction are recent and suggest that there is still much research to be done (Dörner, Focke, & Gutjahr, 2007) (Verter & Lapierre, 2002).

In most Italian hospitals, medical materials (drugs, devices, drugs, etc.) are currently managed maintaining stocks both in the central pharmacy and in the wards pharmacies. This implies:

- Stock oversizing, and related waste of capital;
- Risk of expiration;
- Difficulties in handling emergencies and associated risk of poor service;
- Difficulties in determining real needs and related diseconomies in the purchase process;
- Loss of information and increase in costs for nursing staff.

Landers et al. (Landers, Cole, Walker, & Kirk, 2000) introduce the concept of virtual warehouses as a tool for cooperation aimed to the reduction of costs related to the stock. The perspective is nonetheless fragmented: the study does not provide a systemic approach to logistic health processes and there is a lack of application demonstrations.

3. Intelligent Health Management System

The Intelligent Health Management System (IHMS) is aimed to optimize the management of health materials. The focus is on optimizing logistic processes, concerning drugs and health facilities, within the hospital. For this first stage of the project, activities are concentrated on managing inbound logistics and upstream supply chain: on the one hand, this allows having easier access to the data that are not protected by the privacy law and, on the other hand, it minimize the required change management because it does not concern any change about the doctor-patient interaction. Moreover the use of a properly developed framework can reduce human errors (and related social costs), and then the operational risks associated with medical activities. The IHMS framework will allow to work in two different ways: "peer-to-peer" and "master-slave":

- in the “peer-to-peer” mode some entities (wards, hospitals, pharmacies, etc.) can inform the other nodes of the network about their stock. In this way, taking into account the transfer time (i.e. transhipment), in case of emergency it is possible to exploit the stock of another node of the system. For example it is possible to carry out an internal transfer between two wards of the same hospital and then reduce the need for urgent supplies from the outside. This allows to compensate the natural stock variability between different entities reducing the need to hold large amounts of immobilized drugs. This solution could be particularly valuable for consortia of hospitals and private
clinics owned by the same legal entity because otherwise the management complexity could exceed the savings achievable.

- In the "Master-slave" mode the stock entities may be "supervised" by larger management systems. For example, the central pharmacy of a hospital could have real-time information about the hospital wards or the Local Health Authority could know the stock available in its distribution centers (hospitals and clinics). Therefore, the supervisory body keeps a perfect view on the state of stocks in the various structures and, if necessary, it can also arrange transfers between different structures, based on the needs or expectations of consumption. With this configuration the central unit will formally own the stock until the ward/hospital will need it.

4. Case study: an Italian hospital

The aim of this case study has been the validation of IHMS framework and then its actual ability to increase the performances of a private health organization. This has been proved by using appropriate KPIs (Key Performance Indicators). In particular, this case study has identified the actual applicability of some methodologies, that have been developed in very different contexts, to the health sector.

The context is a private hospital operating in the province of Rome, which provides health coverage for more than 75,000 people. The case study was aimed at assessing the possibility of reducing stock related costs, without compromising the service level, by exploiting the VSS (Virtual Safety Stock) technique.

The hospital has provided data concerning all the orders placed by the wards during the year 2012, with details about every single drug. In particular, data are about:

- 1 year;
- 33 wards;
- about 40,000 material handlings;
- about 750 different codes (drugs and health materials).

Thanks to those data and assuming a constant rate of consumption between two different supplies, consistent with the hypothesis generally adopted in the literature (Hadley & Whitin, 1963), it is possible to compute the amount of drugs/medical supplies in the warehouse of each ward at any time of the year. Moreover, having data about the purchase costs it is possible to compute also the average value of the stock during the year (i.e., working capital). Finally, assuming a weighted average cost of capital (WACC) equal to 8% (estimated using the capital structure of the hospital together with the Italian average costs equity and debt capital) it has been possible to estimate the cost of such immobilization. The results obtained are:

- about € 15.71 million of capital invested in stock during the year 2012;
- about € 1,257,000 of cost of capital invested in stock (computed with an 8% WACC).

The evaluation of the results potentially achievable by adopting the IHMS framework took into account the possibility of sharing the stock among the various wards. This evaluation has been carried out with a simulation of the implementation of the framework over the entire hospital. Only some wards where it is not possible to apply this technique have been kept out from the simulation (e.g., casualty department, ambulance). The simulation was thus able to assess the average level of stock of each drug/medical supplies that could have been obtained with the IHMS framework.
Finally using the same data about purchase costs and the same WACC than in the previous paragraph it has been possible to estimate the same KPIs. As it is possible to see in the following figure 1, the comparison between current and simulated KPIs results in:

- About € 2.45 million of working capital reduction (-15.6%);
- About € 196,000 of saving in interests related to the working capital (-15.6%).

Because of the promising results obtained in this case study, the hospital analyzed has expressed interest in continuing the collaboration. In particular at this moment many meetings are ongoing in order to evaluate the opportunity to make a first pilot project.

5. Conclusions

The comparison between KPIs actually achieved by the hospital in the year 2012, and those which could have reached by using the IHMS framework proposed in this paper, shows a significant reduction of the working capital and, as a consequent, a substantial saving in interest expense associated with it. In addition to economics benefits there are various benefits due to the rationalization of the management process. Among these it should be mentioned the reduction of transport costs due to the optimization of purchase batches. This aspect could have a positive result not only on the environmental impact but probably also allowing the structure to obtain higher discounts from the supplier.

7. References


