The Performance Measurement of Changes in the Logistics of Health Goods: A Theoretical Model*

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Abstract

The aim of this paper is the definition of a measurement system for the evaluation of innovations in the hospitals logistics process. Driven by the need to contain costs and improve the quality of services provided to patients, hospitals are dealing with complex activities of business process reengineering of their critical processes, among which the logistics of health goods. The work differs from previous examinations of logistics performance measurement in that it uses a broader scope, following a Systematic Review of the literature, and it suggests that a logistics innovation evaluation system must consider different performance dimensions, including costs, benefits, quality and safety. The limitations of the research are those related to the theoretical and exploratory nature of the study. From a practical point of view, the work provides an important tool to the management of hospitals involved in logistics innovation evaluation, which are scarcely supported with adequate systems of analysis.

Keywords
performance; measurement; evaluation; logistics; innovation; healthcare

* Fabiana Marras gratefully acknowledges Sardinia Regional Government for the financial support of her PhD scholarship (P.O.R. Sardegna F.S.E. Operational Programme of the Autonomous Region of Sardinia, European Social Fund 2007-2013 - Axis IV Human Resources, Objective l.3, Line of Activity l.3.1.).

1. Introduction

The aim of this study is to present a framework for the selection of an appropriate performance measurement system for the health goods logistics processes. Many countries have been developing conceptual frameworks for monitoring, measuring and managing the performance of their health systems to ensure effectiveness, equity, efficiency and quality. In the early Nineties, the process of corporatization has resulted in the need to introduce performance measurement and management systems in healthcare organizations, overcoming the resistance of professionals and enhancing skills and capacity of healthcare management. The challenges, regarding cost containment and quality improvement, required a strong collaboration for the organizational processes management, so far ruled by rationing of resources and output control, without any real knowledge of the processes and relative performance, from which it derives the absorption of resources and quality of service. In particular, the Public Health Service reformation caused the transition from organizations merely oriented to healthcare service delivery, to those oriented to *clinical governance*. The term was used to capture the range of activities required to improve the quality of healthcare services, among which the development of processes and systems for continuously monitoring and improving the quality of healthcare provided. Clinical governance is therefore the main vehicle through which hospitals are held accountable for the maintenance of high standards of healthcare, for continuously improving the quality of their services and for creating and maintaining an environment in which clinical excellence can flourish (Carbone et al., 2013).

Furthermore, some economic, social and political factors are driving the change, such as expensive and technological advances in medical technology and increasing life expectancy. They are leading to greater demands of healthcare services, with hospitals striving to offer better services at less cost and the reduction of economic resources. In particular, the pharmaceutical expenditure has become more significant in the last few years. As OECD points out, it represents the 15% of Italian public health expenditure, and in the period from Genuary to June 2014 only three Italian regions did not exceed the limit of 3% of the hospital drugs expenditure. But the reduction of pharmaceutical costs requires a transformation that affects not only the processes of diagnosis and treatment, but also those of support, especially *logistics*, which is essential for efficiency, safety of patients and quality improvement. It is of great significance if we think that the weight of logistics activities on the income statement of a hospital can be around 50% of its total costs. However, the logistics management and innovation is even among the most neglected aspects of the system, and very little literature covering both logistics innovation and its evaluation is to be found (Shou, 2013; Vona and Di Paola, 2013). In the hospital setting, the logistics of healthcare goods refers to all the activities ranging from the reception of goods within a hospital, until the delivery of the same to its end user. The mission is to ensure that the right things are in the right place at the right time, managing two distinct flows: the material and the information flows (Bensa et al., 2009; 2010). The material flow is one of the more complex process in an hospital, because it involves differents *activities* – purchasing, inventory management, transportation, returns and expired goods management, annual inventory – and different *actors* – suppliers, hospital pharmacists, nurses and doctors – with problems of coordination and information sharing. In particular, a modern hospital pharmacy service cannot only comply to its "traditional" functions, as managing the drug formulary, supplying, stocking and restoring cabinets, but must also develop new competencies in planning and controlling supply, budget, pharma-economy and quality control, in order to manage resources and optimize processes.

Indeed, various hospitals have recently dealt with a number of ambitious projects in the context of logistics management innovation. The goal is to identify a set of tools and

techniques that support the achievement of the best possible results in terms of quality and safety in the delivery of healthcare services through an efficient use of resources. However, against the growing diffusion of these initiatives, there are still very limited attempts to propose and apply models to assess the performance of these innovations and there is still no coherent method to measure the performance of the logistics process. Therefore, it is hard to make appropriate decisions, and this leads to the deterioration of the overall logistics performance and internal customer satisfaction, and at the same time incurs higher costs for patients. Consequently, it is a fundamental general interests to find a method of measuring logistics innovation performance (Kumar et al., 2005).

In order to achieve the goal of providing healthcare efficiently and cost-effectively, numerous studies and investigations have been done on diagnostic and therapeutic techniques, advanced technology implementations and cost sharing. However, there is little or no research about the performance evaluation of healthcare individual areas, like logistics. Because of changes in financing modalities of public healthcare, the logistics management has to possess a set of tools and methods capable of helping him in both modeling and its evaluation, combining data from physical, informational and financial flows (Chabrol et al., 2005; Kumar et al., 2005). The risk is that the lack of adequate reflection and evaluation of advantages and criticalities induced by logistics innovations will result in the implementation of interventions disconnected from the overall business strategy, with an approach dictated most by individual contingencies, with the sole intention to replay a solution successfully tested in other contexts, without a long term perspective (Boscolo et al., 2011).

In order to fill this gap, this paper aims to contribute to a more complete understanding of the healthcare logistics innovation performance evaluation by reviewing the literature developed in the management research field. In particular, the next paragraph presents an overview about the performance measurement in healthcare and its complexity; in the third paragraph an analysis of the evolutionary dynamics in the health goods management models is proposed. The fourth paragraph is the core of the research, displaying the insights extracted from the literature, which have been articulated and presented in a detailed framework. It differs from previous examinations of logistics performance measurement in that it uses a broader scope, following one of the method of literature review applied to management research, namely Systematic Review (Tranfield et al., 2003; Fink, 2014). Finally, conclusions are presented and areas for further research discussed.

2. Performance evaluation in healthcare

The concept of *performance* is complex, ample and multidimensional. Although it is widely used in all fields of management, its precise meaning is rarely explicitly defined in the literature, even when it is the main focus. It is defined as one of those “suitcase words” in which everyone places the concepts that suit them, letting the context take care of the definition (Lebas and Euske, 2002). For public sector organizations, performance refers to the ability to meet the expectations of different stakeholders, including users and consumers, citizens and financiers, employees and other organizations. Among these, hospitals have long delayed the introduction of advanced performance evaluation systems, but recently, the process of corporatization has required adopting performance measurement and management systems for Italian hospitals (Cagliano et al., 2007; Carbone et al., 2013). Furthermore, the Italian National Health System is based on the principle of universal coverage, financed by general taxation, with a decentralized governance ensuring that national guidelines and targets are implemented across the country through the power and responsibility of regions and provinces managing assigned budgets (Carinci et al., 2012).

Even at international level, public sector reforms have resulted in pressure for many organizations to demonstrate that there have been improvements in performance and that objectives have been achieved, particularly in patient-safety and quality of care issues. Despite calls for the public sector to import managerial processes and behaviors from the private sector, the adoption of private sector business performance models has been viewed with much skepticism, because they still focus on the comparison between used resources and achieved goals, profit and process outcomes, and too little on people and organizational cultures in which they work. This is a limitation, particularly in the healthcare sector, where too much attention on efficiency issues at the expense of others is likely to result in a low-cost but also of poor quality healthcare (Wicks and St Clair, 2006; Moxham, 2009). Hospitals then are moving from purely financial assessment tools to the evaluation and management of the overall *clinical performance*. Measure over the costs and through the analysis of the processes that cross the organization requires: the enrichment of the analysis dimensions; the implementation of multidimensional systems, built to control the various areas of government; the use of both monetary and non-monetary measures (Carbone et al., 2013).

Among the critical areas of intervention to improve the hospital's performance, the *logistics process* is of great significance if we think that it accounts for about 50% of hospitals' total costs. Furthermore, logistics arises not only as an important aspect in the daily operational problems, but also as a strategic opportunity, for the levers that it offers in the management of both costs and service offered to patients. To address complex business problems and pursue continuous improvements, as it is certainly the search for an efficient and effective logistics management, a structured and systemic analysis, careful to obtaining global results sustainable in the medium-long term, is fundamental. But improve performance means first to be able to measure them, and the measurement represents the connection between two moments of the life of each basic process: design, or the birth, and improvement, or growth. Nonetheless, logistics and its improvement initiatives unfortunately don't find a corresponding advancement in the preparation and application of performance evaluation models, that remain sporadic in literature and practice (Kumar et al., 2005; Shou, 2013; Vona and Di Paola, 2013; Ferretti et al, 2014). One reason for this lack of evaluation tools within the logistics process managed by healthcare providers can be found in several difficulties in applying traditional models of performance measurement, which must be adapted in order to take into account three macro areas of *complexity*: a) related to the process to be measured; b) related to the specific characteristic of an healthcare service production; c) related to the public context in which these organizations operate.

2.1 Complexities related to the process object of evaluation

The logistics of goods within hospitals refers to all the activities ranging from the reception of goods until their delivery to end users. Hospitals, unlike other sectors, have traditionally underestimated its importance and strategic relevance, which was hardly identified as a core process of the healthcare system. Over the past two decades the economic and organizational impact connected with the management of consumer goods in healthcare has changed dramatically and several realities have implemented major innovation and change projects (Bensa et al., 2009; 2010).

The reorganization of logistics in healthcare is a goal of fundamental importance to achieve efficiency and quality in the management of the public healthcare service, and proper planning logistics is indeed an undisputed element of competitiveness even for the hospital. Significant results can be achieved only through a new approach to management processes and to physical flows of drugs and medical goods, which before were organized according to a very different perspective, and characterized by dispersion and fragmentation. The increased complexity that characterizes the logistics process within hospitals is due also to different

aspects (Pinna et al., 2015): firstly, logistics manage different categories of goods characterized by markedly different physical, logical and managerial requirements (drugs, medical devices, healthcare material, economic goods); secondly, logistics organizational responsibility is often fragmented and dispersed among numerous organizational units with coordination and integration problems (pharmacy, purchases, logistics, information systems, wards); last but not less important, logistics has an important impact on the processes of patient care, that is on the quality and safety of care provided to people.

2.2 Complexities related to the production of a healthcare service

The healthcare sector has historically distinguished, in terms of operations management, compared to other sectors. In fact, it is difficult to predict and manage the production plans and the utilization of production factors, although several studies have shown that a part of the hospital production variability is artificial and therefore can be controlled and managed, opening spaces for the introduction of innovative solutions. Critical for the innovation process is the involvement and awareness of clinical professionals who, traditionally, have a key role and are often concerned that the research of operational efficiency jeopardize the supply and availability of drugs and life-saving devices. Moreover, hospitals have to consider some dimensions of little importance in other contexts, such as security, pertinence of use, multiplicity and heterogeneity of products, special storage conditions, which require special care in the organization of the various phases of logistics (Boscolo et al., 2011).

Managerial complexity in healthcare can be connected to three sub-systems respectively of economic, structural and organizational type. The optimization of the system operation and performance as a whole, therefore, requires the interaction between very different disciplines ranging from medicine to economics, management and organization, as well as social. Too much attention on efficiency to the detriment of the others is likely to result in a poor quality low-cost healthcare. In all cases, measurement difficulties depend on the scarcity and lack of consistent tools, both nationally and internationally. This criticality suggests first to lean towards composite measures, which can correct the distorting effects caused by taken each measure individually; second, not to disdain qualitative methodologies, which can give greater emphasis to the importance of the human component in the process. All this, of course, seems to go well beyond the scope of "simple" technical measurement of logistics performance, to which classical systems of evaluation are focused on (Vona and Di Paola, 2013).

2.3 Complexities related to the public context

There are numerous public sector peculiarities that can affect the logistics management in a hospital. Firstly, the influence of *politics* on management decisions with respect to objectives and time horizon, which can limit the effectiveness of strategic choices. Secondly, the multiplicity of *stakeholders*, which can determine some management choices interpretable as tools to achieve the purposes of an economic, social and environmental purposes. Thirdly, the public bureaucratic model, characterized by formal and transparent decision-making processes, designed to ensure competitiveness and equity among suppliers, in some cases can limit the management decisions and reduce their impact in terms of efficiency, compared to other sectors. However, public organizations have also some advantages, among which a better propensity to collaborate in a network logic and the possibility to influence suppliers (Boscolo et al., 2011).

3. Evolutionary dynamics in the management models of health goods

3.1 The traditional management system of health goods

The management of health goods process includes all the operations ranging from the prescription to the administration to patients, including two main components: the *therapy* and the *inventory* management. Traditionally, a hospital manages goods in stock, in order to ensure a provision in both the central pharmacy and especially at the ward level. In particular, health goods delivered from providers are stored in warehouses and then picked up for distribution to wards in the same packs prepared by suppliers. Once arrived in the wards, goods often don't find a precise location, but they are placed in rooms used for storage, sometimes without any codification. The flow of health goods within the hospital, generally involves two major organizational units: the *wards* and the *pharmacy*. They perform a series of interconnected activities: a) at the ward level, the prescription definition by the doctor and its subsequent transcription in the register by nurses; the staging of the ward cart by the head nurse or by nurses; the preparation of prescribed drugs and their administration to patients by nurses; the ward needs analysis; withdrawal or purchase requests to the pharmacy; receipt and storage of goods in the ward; b) at the pharmacy level, all procedures to collect goods from the warehouse, prepare and distribute them to wards; the under-provision analysis; the orders and reminders management.

This traditional system of health goods management manifests a series of problems, starting from the high value of provisions accumulated and managed in the central warehouse and in wards, which is associated with the increasing risk of goods obsolescence; secondly, the major difficulties encountered by the hospital staff in controlling the wards consumption; thirdly, a significant waste of time spent by administrative and medical staff in activities related to the management of health goods; again, the highly unpredictability of wards requests and the high risk of error in the phases of association patient-therapy, manual transcription of prescriptions, preparation and administration of drugs. In addition to these problems closely related to the management of health goods, there are those emerging from the process of corporatization, which, as above mentioned, has established the introduction of control mechanisms in the National Health System, and has attributed to hospitals economic and financial autonomy. Hence the need to set clear objectives for quality of service and cost management, given limited resources and expenditure in constant growth (Cagliano et al., 2007; Carbone et al., 2013).

All of these conditions require a major change, which should involve not only the processes of diagnosis and treatment, but also those of support, among which emerges the logistics of health goods. Therefore, only recently hospitals have well considered the weight of expenditure in health goods and their management in the balance sheet, recognizing the need for change in the way of i) simplifying the flow of goods and ii) burdening the flow of information, which must be accurate, timely and available in real time at all stages of logistics. For these reasons, several hospitals are currently experimenting innovative systems for managing health goods.

3.2 Main innovations in the management of health goods

A first attempt to change and innovate the logistics of health goods in hospitals is the experimentation of the *Just in Time* (JIT) philosophy, developed successfully in the manufacturing sector in the Seventies. JIT is based on eliminating wastages from the production process and on obtaining high-volume output with the use of minimum stocks of input, key objectives also for a hospital.

Another solution experimented in the healthcare sector is the *Kanban carts* system, which is based on the use of accompanying goods cards that manage orders and inventory

movements, according to the FIFO logic. Health goods are stored in the warehouse, picked according to a logic of ward provision replenishment and then distributed through the use of pairs of "twins cabinet carts" containing all goods used by the ward, which transit from pharmacy to wards.

Intelligent carts use bar codes or radio frequency identification (RFID) technologies. Packages of goods are marked with a label containing all product information, stored in the pharmacy warehouse and picked on the basis of requests for the distribution to ward cabinets through an intelligent cart. The cart is equipped with a laptop and an optical reader for barcodes or RFID tags, and it allows the accounting unload of goods taken from the ward cabinet and the simultaneous load to cart.

The *computerized or automated cabinet* consists of cabinets with a management software that registers provisions and all movements of goods. It is able to track electronically the operator access to the system as well as the patient to whom the drug has been prescribed, providing data for the analysis of costs incurred at individual patient level. These type of cabinets can contain original packaging of goods and unit doses, and can be connected to reading devices at the patient bed, allowing the administration control via identification bracelets. In addition to the therapy management, it is also possible the inventory management with the automatic issuance of orders to the pharmacy.

With the *computerized prescription* system the doctor records the prescription in an appropriate computerized device and it is automatically associated to the patient with an electronic bracelet. This has enabled the transition from manual recording of paper documents to electronic record, with the resulting creation of *computerized medical records* and with the reduction of all errors related to the interpretation of what manually written.

The *unit dose system* has greatly changed the inventory management from a physical, technological and informational point of view. It provides that health goods are divided into single-doses through dedicated automated machinery; they are then labeled with a bar code, stored in the warehouse, taken on the basis of requests and distributed through manual or automatic dispenser. In wards, nurses equipped with barcode readers draw from the dispenser all single-doses packages necessary for each administration.

The unit dose evolution is the *personalized dose system*, which automates the entire process of managing health good through the use of computer technology. Unit doses flow into customized packets of therapy prepared for each patient by the pharmacy, on the basis of prescriptions received from wards. Each packet is then labeled with specific data about the single administration and is then ready to be distributed to wards.

These different innovative solutions can be seen as independent modules interacting between them. It is therefore possible to activate one or more systems, through the implementation of mixed solutions, according to the specific needs of each structure (Cagliano et al., 2007; Bensa et al., 2009).

4. Evaluation systems in the health goods logistics innovation process

4.1 Methodology

In compliance with the theoretical framework presented in the previous paragraphs, the evaluation system of the processes of change and innovation in the logistics of health goods has been defined from the results of a Systematic Review of the literature (Tranfield et al., 2003; Fink, 2014). A Systematic Review is a research methodology characterized as being a methodical, transparent and reproducible method of analyzing existing literature. It both maps and assesses the relevant literature and provides collective insights through the theoretical synthesis of a field. Systematic reviews differ significantly from traditional narrative reviews,

because they clearly specifies how the researcher conducts the review, what type of documents have been reviewed and where those documents can be found, in order to allow other researchers to replicate the investigation. In particular, health *and* logistics innovation *or* supply chain innovation *and* evaluation *or* measurement have been used as keywords in a computerized search conducted in a number of top-level management journals within the time range 2000-2014. After a screening process entailing removing duplicated articles, title screening, abstract screening and full-text screening, 13 studies were included in this review (see Tables below). The description of the step-by-step development of the review has been omitted for clarity and conciseness, because here the focus is on the method used for synthesizing the literature reviewed. Indeed, once the search and study selection has been carried out, the information can be analyzed either *descriptively* or *thematically*. The descriptive analysis helps to clarify the main characteristics of the field (methodologies used, classification of countries and industries studied), whereas the main purpose of the thematic analysis, which consists of synthesizing the main outcomes extracted from the literature, is to inform future research and practice. Considering the aim of the research, this paper only presents the latter.

4.2 Findings

The mission of a hospital is to provide a high service level to patients respecting a fixed budget, and its pursuit goes through a series of objectives of *quality* of health services provided – *effectiveness* – and containment of costs – *efficiency* – . In particular, effectiveness measures how successfully the system achieves its desired outputs, while efficiency measures how successfully inputs have been transformed into outputs. From the strictly point of view of managing the logistics process, *logistics effectiveness* is defined as the extant to which, by choosing a certain course of action, a previously established goal or standard is being met. Further, *logistics efficiency* is defined as the relationship between planned and actual sacrificies made in order to be able to realise a goal previously agreed upon (Kumar et al., 2005; Cagliano et al., 2007). Logistics effectiveness and efficiency are strictly related to the *quality* of the service provided and the *cost* of such delivery (Vona, di Paola, 2013; AbuKhousa et al., 2014). As already said, a logistics system creates value when it meets customer needs by providing the right product, in the right quantities, in the right conditions, in the right place, at the right time, ensuring the desired service level at the lowest total cost. This general definition particularly applies to the healthcare sector, where, as has already been pointed out, the logistics performance has characteristics peculiar to the type of activity managed (Bensa et al., 2009; Chikumba, 2010).

The logistics process must be measured in a way that lets the decision-maker understand how the efforts affect the results, and the performance measurement system is supposed to provide the management with unbiased and objective information, which constitutes a powerful source for improving the logistics operations. As a consequence of the definitions of efficiency and effectiveness mentioned above, logistics performance can be considered as the extent to which the logistics function is able to realize its predetermined goals at the sacrifice of a minimum of the organization's resources. The design of a reliable and effective measurement system has to include some kind of business model or mental model of the system as a whole. The most important factor that determines the type of measurement for assessment of performance is the status of the logistics department in the organization: organization where logistics department have a low, clerical status seems to focus only on operational efficiency measures, while in organizations where the logistics department has a higher status, combination of both the operational efficiency measures and effectiveness-related measures are used. As mentioned above, logistics involves numerous activities, consisting of many material and information flows. It is not as simple as to just convey a need

from an internal customer to a supplier and then deliver the item to the internal customer. Instead, this process consists of activities that are continuously changing in intensity, duration and quality, thus producing variations in performance, efficiency and effectiveness of the logistics. Another aspect worthy of consideration is the fact that, as already said, the logistics process involves several activities managed by different organizational units, wards and the pharmacy. The objective of the evaluation will therefore understand how the activities managed by them have changed with the introduction of the innovation, for each dimension of analysis considered. Consequently, a single performance measure is generally inadequate, as it is not inclusive, because it ignores the interactions among these important units and ignores critical aspects of organizational strategic roles. The actual measurement should consist of a set of generic measures to illustrate the performance of the main components and their relationships. The key elements that should be investigated in the logistics performance measurement system are resources, procedures and outputs: resources are dependent on what the logistics department can provide; procedures are the material and information flows; outputs are the objectives and the degree of customer satisfaction (Kumar et al., 2005).

In particular, literature highlights a number of performance indicators that should be considered for the evaluation of changes in the logistics process of hospitals, which fall into four dimensions of analysis: costs, benefits, quality, safety.

4.2.1 Costs

Cost is an important factor of overall healthcare management performance. Hospitals are seeking to implement cost reduction initiatives in their logistics processes, which represent a previously untapped source of financial resources. The movement of goods within a hospital involves incurring costs classified into two main categories: costs strictly related to the management of *goods* and cots strictly related to the management of the *process* (Tab. 1).

The first category entails all costs related to the management of healthcare goods, and from the literature, it is possible to consider several components. The *unit* cost is the cost or price of the item purchased, relevant to evaluate savings in purchase prices in terms and economy of scale due to the innovation adoption (Rivard-Royer et al., 2002; Bensa et al., 2009; 2010; Boscolo et al., 2011; Ivan Su et al., 2011). The *acquisition* costs are related to acquiring the product, including overhead, equipment and supplies used in the process of acquisition (Rivard-Royer et al., 2002; Rossetti and Liu, 2009; Shou 2013). The *possession* costs are associated with holding, managing and controlling inventory in the warehouse and other areas where supplies are stored, including stock-out costs for both finished and raw goods (Rivard-Royer et al., 2002; Rossetti and Liu, 2009; AbuKhousa et al., 2014). The *transaction* costs are related to preparing and managing the documentation used to account for the entire process (Rivard-Royer et al., 2002). The *distribution* costs are related to moving supplies throughout the hospital, whereas the *operation* costs are related to assembling and preparing material for use (Rivard-Royer et al., 2002; Rossetti and Liu, 2009). The *utilization* costs concern using the product in its intended clinical application (Rivard-Royer et al., 2002), while the *shortage* cost is the cost paid when customer orders are not met (Rossetti and Liu, 2009). Within the second category, there are those costs strictly related to the management of the process itself, among which the cost of the used *technology* (Bensa et al., 2009; 2010; Boscolo et al., 2011); the logistics *personnel time* spent for manual operations like internal material request processing, inbound material receipt, outbound material delivery, order pickup and external procurement (Bensa et al., 2009; 2010; Boscolo et al., 2011; Ivan Su et al., 2011); the *storage space* occupied that can be adressed for other hospital healthcare purposes (Bensa et al., 2009;2010; Boscolo et al., 2011; Ivan Su et al., 2011); the cost of *maintenance* (Bensa et al., 2009; 2010) and the cost of any *outsourced services* (Bensa et al., 2009; 2010; Boscolo et al., 2011).

Tab. 1. Cost perspective drivers

COST PERSPECTIVE	DRIVER/INDEX	FORMULATION	AUTHORS
COSTS FOR THE MANAGEMENT OF GOODS	*Unit* cost	The cost or price of the item purchased.	Rivard-Royer et al., 2002; Bensa et al., 2009; 2010; Boscolo et al., 2011; Ivan Su et al., 2011.
	Acquisition costs	The overall cost related to acquiring the product.	Rivard-Royer et al., 2002; Rossetti and Liu, 2009; Shou 2013.
	Possession costs	The cost associated with managing inventory.	Rivard-Royer et al., 2002; Rossetti and Liu, 2009; AbuKhousa et al., 2014.
	Transaction costs	The cost related to managing documentation.	Rivard-Royer et al., 2002.
	Distribution costs	The cost of moving supplies.	Rivard-Royer et al., 2002; Rossetti and Liu, 2009.
	Operation costs	The cost of preparing material for use.	Rivard-Royer et al., 2002.
	Utilization costs	The cost of using the product.	Rivard-Royer et al., 2002.
	Shortage cost	The cost related to orders not met.	Rossetti and Liu, 2009.
COSTS FOR THE MANAGEMENT OF THE PROCESS	*Technology*	The cost of the used technology.	Bensa et al., 2009; 2010; Boscolo et al., 2011.
	Personnel time	The cost related to the personnel time	Bensa et al., 2009;2010; Boscolo et al., 2011; Ivan Su et al., 2011.
	Storage space	The cost for the storage space occupied.	Bensa et al., 2009;2010; Boscolo et al., 2011; Ivan Su et al., 2011.
	Maintenance	The cost for the maintenance of spaces and technologies	Bensa et al., 2009; 2010.
	Outsourced services	The cost of any outsourced services	Bensa et al., 2009; 2010; Boscolo et al., 2011.

Source: our elaboration

The purpose of the measurement is to understand what savings have been obtained with the logistics innovation introduction, compared to the previous situation, for each dimension of cost considered.

4.2.2 Benefits

The second dimension of analysis groups together those indicators that can measure what benefits have been generated by the logistics innovation, both at economic and organizational levels.

Tab. 2. Benefit perspective drivers

BENEFITS PERSPECTIVE	DRIVER/INDEX	FORMULATION	AUTHOR
ECONOMICS BENEFITS	*Inventory*	The value of inventory.	Bensa et al., 2009; 2010; Boscolo et al., 2011; Ivan Su et al., 2011; Shou 2013; AbuKhousa et al., 2014.
	- turnover rate	Goods distributed value/ stock average value.	
	- coverage ratio	(Goods in stock average value/consumed goods value)*365 days or *52 weeks.	
	Ward provisions	The value of ward provisions.	Bensa et al., 2009; 2010; Ivan Su et al., 2011; Shou 2013; AbuKhousa et al., 2014.
	Expired inventory	The value of expired inventory.	Bensa et al., 2009; 2010; AbuKhousa et al., 2014.
ORGANIZATIONAL BENEFITS	*Appropriateness*	Healthcare goods appropriateness of use.	Bensa et al., 2009; 2010; Boscolo et al., 2011.
	Standardization	Product and process standardization.	Bensa et al., 2009; 2010; Boscolo et al., 2011.
	Specialization	Professional specialization and knowledge management of employees.	Bensa et al., 2009; 2010.
	Suppliers relationship	A better management of suppliers relationship.	Bensa et al., 2009; 2010; Boscolo et al., 2011.

Source: our elaboration

As stated above, one of the biggest challenges facing healthcare logistics operationally is maintaining sufficient *inventory levels* to sustain quality and timely patient care. Consequently, due to the fact that too much inventory often leads to a high product expiry rates, the consequent big problem is *wastage*. The inventory in a healthcare supply chain forms a major part of the cost, and it is often viewed as a potential source for revenue: having an overstock of inventory adds to organizations opportunity costs, that is money would have otherwise been spent elsewhere within the organization. Increasing inventory levels depend on a number of factors that healthcare organizations have to deal with, among which i) proper planning, ii) appropriate inventory level control and, iii) budgetary guidelines monitoring. Additionally, in an effort to adress the consumer demands, the hospital need to keep plenty of everything, with resulting higher costs. Moreover, a considerable amount of inventory is moved on a daily basis, and it is then necessary to maintain appropriate stock levels of those

items, many of which are quite costly. The main challenge is then to find and maintain inventory balance so that hospital budgetary requirements and consumer demands are met (Shou, 2013; AbuKhousa et al., 2014).

The logistics performance is therefore evaluable through an analysis of its ability to optimize the flow of goods in order to minimize the value of stocks, releasing financial resources. Therefore, with regard to economics benefits, literature provides at least three areas of possible recovery (Tab. 2): the *value of inventory*, which can be evaluated through two non-monetary indicators, the *turnover rate* and the *coverage ratio* (the former is the ratio between the value of goods distributed and the average value of the stock held in the warehouse; the latter indicates the temporal coverage of requirements and it can be expressed in days – the average value of goods in stock divided by the value of goods consumed multiplied by 365 – or weeks – the same indicator multiplied by 52 –) (Bensa et al., 2009; 2010; Boscolo et al., 2011; Ivan Su et al., 2011; Shou 2013; AbuKhousa et al., 2014). Additionally, the *value of wards provisions* (Bensa et al., 2009; 2010; Ivan Su et al., 2011; Shou 2013; AbuKhousa et al., 2014) and the *expired inventory value* (Bensa et al., 2009; 2010; AbuKhousa et al., 2014).

In addition to economic benefits, literature shows that logistics innovation also determines several organizational benefits, including (Bensa et al., 2009; 2010; Boscolo et al., 2011): a better *appropriateness* of use of healthcare goods (in particular drugs and medical devices) through improved information systems and traceability projects; product and process *standardization*, through the better involvement of nurses and physicians, as well as technical and administrative personnel; professional *specialization* and knowledge management of the employees more involved in the innovation implementation, through the definition of new professionals and the higher qualification of the existing ones; a better management of *suppliers relationship*. As with the other logistics performance dimensions, the objective of the measurement is to understand what benefits have been achieved with the introduction of the innovation, compared to the previous situation, for each aspect considered.

4.2.3 Quality

Healthcare quality ensures that patients receive safe therapies and that problems are contained and minimized. In particular, successful hospital performance at all levels depends on both technical and functional aspects of care: *technical* quality means the elimination of medical errors and adverse events, which means security, while *functional* quality relate to how care is delivered. Because most patients are not able to evaluate the technical quality unless an adverse event occurs, patient satisfaction often is based on functional aspects of care and the cost of care.

While patients are the primary and ultimate customers of the healthcare provider, and providers exist to meet the real and perceived needs of these customers, it is the quality of the provider's internal processes that ultimately determines how those needs are met. Then, the quality of the logistics process can be seen as the *internal customer satisfaction***,** which is a comprehensive measure of how well the processes meet the needs of their customers (Swinehart and Smith 2005;Wicks and St Clair, 2006; Shou, 2013), in terms of (Tab. 3): *nursing shortages*, because patients expect prompt interventions from nurses when they place calls, so delays that result from understaffing can reduce satisfaction (Wicks and St Clair, 2006); consequently, another quality driver is the speed and reliability of *response* (Vona, Di Paola, 2013); again, the *lack of adequate technology*, which is essential for the service quality improvement, although high implementation costs and cultural barriers are slowing the adoption of new technology programs in hospitals; *poor internal communication systems*, that, in addition to enhancing the benefits of physicians-patient communication, improves the technical and functional aspects of patient care (Wicks and St Clair, 2006); *frequency of*

deliveries in order to maximize timely access to the required drugs (Bensa et al., 2009; 2010; AbuKhousa et al., 2014); correspondence between goods *ordered* and goods *delivered* to wards (Vona, Di Paola, 2013; Shou 2013); *workloads distribution*, to which the latest innovation are oriented, with the aim to minimize time-consuming activities and then obtain resources for core activities of treatment and care of patients (Bensa et al., 2009; 2010; Boscolo et al., 2011; Ivan Su et al., 2011); *accuracy* and *timeliness* of information, in order to improve control mechanisms for costs at ward or business unit level together with clinical governance policies focused on the elimination of inappropriateness areas and projects of care pathways standardization; finally, the goods *traceability* level (Bensa et al., 2009; 2010). These issues directly affect technical and functional aspects of care together with the cost of care, resulting in an even more negative impact on patients' overall satisfaction with their healthcare experience. Even for quality indicators, the objective is to understand what changes have been obtained with the introduction of innovation compared to the previous situation, for each dimension considered.

Tab. 3. Quality perspective drivers

QUALITY DIMENSION	DRIVER/INDEX	FORMULATION	AUTHOR
	Nursing shortages	Level of nursing shortages in wards.	Wicks and St Clair, 2006.
	Response	Speed and reliability of response.	Vona, Di Paola, 2013.
	Adequate technology	Lack of adequate technology.	Wicks and St Clair, 2006.
	Communication	Poor internal communication systems.	Wicks and St Clair, 2006.
	Deliveries	Frequency and precision of deliveries	Bensa et al., 2009; 2010; AbuKhousa et al., 2014.
	Orders	Correspondence between goods ordered and delivered.	Vona, Di Paola, 2013; Shou 2013.
	Workloads distribution	Organization of personnel time	Bensa et al., 2009;2010; Boscolo et al., 2011; Ivan Su et al., 2011.
	Information	Accuracy and timeliness of information.	Bensa et al., 2009; 2010.
	Traceability	The level of goods traceability	Bensa et al., 2009; 2010.

Source: our elaboration

4.2.4 Security

Security is certainly one of the dimensions of performance that deserves more attention and that has strongly affected the decisions about the logistics of healthcare organizations in recent years. The activities considered at highest security risk are those engaged in the ward, such as the *storage* of health goods (management of cabinets, way of storage in trucks) and all

the operations relating to the drug *administration* to patients beds (request transmission, drug therapies transcription).

Tab. 4. Security perspective drivers

SECURITY DIMENSION	DRIVER/INDEX	FORMULATION	AUTHOR
	Errors	Probability of making errors.	Wicks and St Clair, 2006; Cagliano et al., 2007; Bensa et al., 2009; 2010; Boscolo et al., 2011.

Source: our elaboration

The safety level of the logistics process is measured by the probability of making *errors* in all stages of drug management (Tab. 4). In particolar, *error* is defined as any preventable event that may cause the misuse of health goods or a demage to a patient when the property is under the control of the health professional, patient or consumer. This event can occur at any time of the process of managing health goods and then it can be expressed in terms of: *prescription* error, when it concerns the medical act of prescription and it can be related to the wrong choice of the medication or an illegible or misleading prescription; the *transcription*/*interpretation* error occurs when the prescription, mostly handwritten, is not properly reported, transcribed or interpreted; the *therapy preparation* error is generated by an incorrect formulation or handling of a pharmaceutical product before administration; the *distribution* error includes those errors that can occur during the distribution of drugs; *administration* errors are caused by a change in what the doctor prescribes in the medical record. The purpose of measuring, as in the previous, is to understand which improvements have been obtained with the introduction of innovation compared to the previous situation for each of the two indicators considered. Note that in this area of activities the latest innovations of healthcare logistics are mostly focused on, such as the distribution in unit dose, computerized cabinets, patient-therapy control systems, automated carts and so on (Wicks and St Clair, 2006; Cagliano et al., 2007; Bensa et al., 2009; 2010; Boscolo et al., 2011).

5. Conclusions

The corporatization process of healthcare companies has focused on the efficient use of resources. This resulted in the need to reconfigure the hospital logistics process and, in particular, the management of healthcare goods, the importance of which is essential for the provision of healthcare services to patients. In a context in which the National Health System has begun to understand that the hospital logistics is an important lever to achieve savings and to improve the quality and safety of care processes, the present paper presents a system for the analysis of the impact, in terms of costs, benefits, quality and safety of the innovation of the logistics process. The system adopts a multidimensional approach, considering both the economic perspective and the clinic one and analyzing the logistics process in its interlinked activities. Despite several limitations related to the exploratory nature of the research, it can be a valuable support for the management of the hospitals, asked to evaluate important innovation projects in the logistics process. The evaluation system presented here will be tested empirically with its application to a case study in order to understand what dimensions and related indicators, among those identified, are more significant for the analysis and the measurement of innovations in the logistics process.

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