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The Healthcare Goods Logistics Innovation Evaluation: Theoretical Foundations and Practical Applications

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"To improve is to change; to be perfect is to change often."

Winston Churchill

Abstract

The research presented in this thesis is focused on innovation in the health goods logistics process managed by hospital companies, with particular reference to the systems for the evaluation of its performance. It can be seen as an initial observation of the current knowledge in the context of healthcare goods logistics innovation within hospital companies (*chapter 1*); an initial deduction, from the literature, and explanation of a model for the healthcare goods logistics innovation performance measurement (*chapter 2*); an initial testing of the validity of this model and comparison with other systems of evaluation that emerge from the analysis of a case study (*chapter 3*). The thesis has the objective to offer a managerial support for the innovation performance evaluation of the healthcare goods logistics process managed by hospital companies.

In particular, the purpose of the first article is to present a theoretical framework of the healthcare goods logistics process and its innovation within hospitals, that is, the process which includes all the activities from receiving healthcare goods until their delivery to patients. In contrast to other contexts, in healthcare the strategic importance of this process has only recently been recognised: it is essential for service differentiation and quality improvements, playing a central role in supporting the efficient operational functioning of hospitals. Although this is an important issue both theoretically and in practice, there has so far and to the best of our knowledge been no attempt to systematically review the literature examining hospital logistics process and its innovation. Therefore, in order to address this deficit, a Systematic Review of selected peer-reviewed articles is presented, providing a more complete understanding of the theme and focusing on concepts

and definitions, process organisation, models, types of innovations and their conditions.

The second paper aims to define a measurement system for the evaluation of innovations in the logistics process within hospitals. Driven by the need to contain costs and improve the quality of services provided to patients, hospitals are dealing with the complexities of business process reengineering of their critical processes, among which are the logistics of health goods. 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. 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 its suggestion that a logistics innovation evaluation system must consider different performance dimensions, including costs, benefits, quality and safety. From a practical point of view, the work provides an important tool for the management of hospitals involved in logistics innovation evaluation, which are currently supported with inadequate systems of analysis.

The objective of the third study is to identify any problems and inefficiencies in the logistics innovation evaluation system adopted by a hospital company and to define possible paths for improvement. The study is undertaken through combining a review of the literature and an empirical exploratory investigation, the latter conducted through qualitative methodology based on a case study. The focus of the case study is the Azienda Ospedaliero Universitaria Cagliari, a hospital affected by the experimentation of new organisational and technological solutions for the management of the healthcare goods logistics process. The results of the analysis document how the performance of the new method of management of healthcare goods logistics can be defined in terms of benefits to the economic,

organisational, quality and process safety aspects. From the research conducted, and on the basis of a comparison with more complex approaches and measurement systems, it is clear that a logistics performance evaluation system which is based on only a limited set of indicators has evident criticalities. This study provides suggestions and guidelines for the design of a more articulated and complex tool to monitor the performance of the healthcare goods logistics process in order to improve the approach and the evaluation system currently adopted by the hospital management. It also contributes to the literature on hospital management through adopting a current research perspective.

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Chapter 1

The healthcare goods logistics process and its innovation: a systematic review of the literature

1.1 Abstract

The purpose of this study is to present a theoretical framework of the healthcare goods logistics process and its innovation within hospitals, that is, the process which includes all the activities from receiving healthcare goods until their delivery to patients. In contrast to other contexts, in healthcare the strategic importance of this process has only recently been recognised: it is essential for service differentiation and quality improvements, playing a central role in supporting the efficient operational functioning of hospitals. Although this is an important issue both theoretically and in practice, there has so far and to the best of our knowledge been no attempt to systematically review the literature examining hospital logistics process and its innovation. Therefore, in order to address this deficit, a Systematic Review of selected peer-reviewed articles is presented here, providing a more complete understanding of the theme and focusing on concepts and definitions, process organisation, models, types of innovations and their conditions. The limitations of the study are related to the theoretical and exploratory nature of the research. The paper consolidates current academic research on hospital logistics innovation, providing a comprehensive multi-dimensional framework, which can both support further research as well as lead decisions on logistics innovation and change within hospitals.

1.2 Introduction

The main purpose of this article is to present a theoretical framework of the healthcare goods logistics process and its innovation within hospitals, that is, the process which includes all the activities from the

point of receiving health goods (drugs and surgical medical products) in the hospital until their delivery to end users (patients). This is an important issue on the international research agenda as well as in practice, and new business models based on new ways of designing logistics flows have emerged during previous decades (Ivan Su et al., 2011; Lee et al., 2011). Healthcare issues are currently the focus of attention due to economic and political factors: the aging population, the increasing demand for healthcare services, the rising cost of inpatient and outpatient care, shortages of professionals, new technologies and new health goods, which combine to drive up the total cost of healthcare (Chunning and Kumar, 2000; Cagliano et al., 2007; Bensa et al., 2009). Hence, hospitals are starting major projects of innovation and change aiming towards the reconfiguration of corporate operations, namely the choices regarding the management of logistics flows (goods and people) and processes (activities, operating procedures, input streams). In manufacturing companies, the strategic importance of the logistics function has long been recognised and it is widely accepted that a well-designed and well-managed logistics system can enable a competitive advantage in terms of higher quality and production efficiency, compared with the lower costs and production times of competitors. This also applies to the healthcare sector, where the need to have all clinical processes at the right time and in the appropriate place is a prerequisite to guaranteeing adequate levels of safety and quality. In addition, the effective management of inputs ensures time optimisation, cost reduction and thus the improvement of the overall business. Despite these considerations, to date, the logistics function in hospitals has received limited attention. This can be explained by a number of different factors. Firstly, the concept of logistics in a healthcare context is particularly complex since

it may relate to people, i.e. moving patients between various departments, and materials, i.e. health goods, information, technology. Secondly, hospitals manage two different macro categories of processes: clinical and support. The former are governed by professional reasoning and tend to evade the rules of the organisation, while the latter are governed by bureaucratic rules and procedures (Villa et al., 2007). Thirdly, hospitals are complex distribution networks composed of storerooms providing multiple stock locations for medical supplies. They often operate individually, with their own purchasing offices, an internal pharmacy and distribution systems based on order-delivery processes. Consequently, numerous transactions are sent to different vendors and large quantities of goods are purchased from individual wards, with a consequential generation of inventory and storage costs. As a result, the organisational responsibility for the logistics process is fragmented and dispersed across multiple organisational units, with clear resulting coordination and integration problems (Rivard-Royer et al., 2002; Landry and Philippe, 2004; Cagliano et al., 2007; Bensa et al., 2009). There are some fundamental reasons why the way in which hospitals manage healthcare facilities needs to change: on the one hand, the process of hospital companies' corporatisation, which involves the introduction into the National Health System of control mechanisms, similar to competitive market models. As a result, hospitals have assumed managerial and economic-financial autonomy; now they must set their own goals for quality of service and cost management in order to ensure survival over time. On the other hand, they have limited resources and a steady growth in spending, hence, the need for a public health rationalisation, especially for meeting increasing quality demands. Such factors require a profound transformation that affects not only the processes of diagnosis and treatment, but also those of

support, especially logistics, which is essential for the processes of service differentiation and quality improvement. In particular, the health goods logistics process assumes a central position in ensuring efficient operational functioning in healthcare. Since it is crucial for hospital operations, an efficient internal organisation is required; this is extremely difficult given the complexity surrounding the process (Cagliano et al., 2007; Bensa et al., 2009). We believe there is significant activity in this area of healthcare improvement and innovation and it is clear that there are large areas of intervention in logistics, with possible improvements in efficiency, quality and safety processes. Compared to the amount of activity, however, there is very little literature covering both logistics processes and their innovation: little has been published, publications are hard to find and the evidence is scattered and almost impossible to compare (Elkhuizen et al., 2006; Ivan Su et al., 2011). Moreover, there has been so far and to the best of our knowledge no attempt to systematically review the literature examining hospital logistics processes and their innovation. This paper aims to address this deficit by providing a systematic review of selected peer-reviewed articles in order to present a more complete understanding of the hospital logistics innovation process, focusing on concepts and definitions, models, its organisation and innovation conditions. The article will firstly describe the method applied to identify, select and highlight the relevant literature; in the following section it provides an in-depth presentation of the findings, and finally, the fourth section concludes and suggests areas for further research.

1.3 Methodology

Undertaking a review of the literature to provide the best evidence for informing policy and practice in any discipline is a key research objective for academic and practitioner communities. In management research, the literature review process is a key tool, used to manage the diversity of knowledge for a specific academic inquiry. The aim of conducting a literature review is often to enable the researcher both to map and to assess existing intellectual territory. A research literature review is a systematic, explicit and reproducible method for identifying, evaluating and synthesising the existing body of completed and recorded work produced by researchers, scholars and practitioners. Systematic reviews differ from traditional narrative reviews by adopting a replicable, scientific and transparent process, in other words a detailed technology that aims to minimise bias through exhaustive literature searches of published and unpublished studies and by providing an audit trail of the reviewers' decisions, procedures and conclusions. Generally, the review process consists of three stages: data collection, data analysis and synthesis. The scientific rigueur in the conducting of each of these steps is of fundamental importance for a quality review (Tranfield et al., 2003; Fink, 2014).

Data collection. Data can be collected by researchers in different ways, but a systematic review approach avoids subjective data collection by using a predefined selection algorithm. Specifically, "health" and "logistics innovation" or "supply chain innovation" (and their derivatives) were used as keywords within the "topic" search function of Web of Science, Scopus and Google Scholar. It was considered appropriate to use this broader approach rather than limit the search for articles using the "article titles, abstracts and keywords" search option, which would probably exclude relevant contributions (Mention, 2012). A computerised search using these keywords was conducted in top-

level management journals, pertaining to the following domains: Management; Health Policy & Services; Healthcare Management; Operations Research & Management Science; Health & Social Care; Nursing. In order to be included in this review, a study had to comply with the following practical criteria: firstly to be an article published in English or in Italian and secondly to have been published between the years 2000 to 2014. In addition, the following quality criteria were applied: theoretical, methodological and empirical papers using qualitative or quantitative methodologies are considered; some information on research design is provided, the question of generalisability is raised; some implications for practice are mentioned; and an abstract is provided. In particular, quality assessment refers to the appraisal of a study's internal validity and the degree to which its design, conduct and analysis have minimised biases or errors. The relevance of a study to this review also depends on the relevance of its research questions and the quality of its methodology. The strict criteria used in a systematic review are linked to the necessity of basing reviews on the best-quality evidence.

Data analysis. The computerised keyword search identified 536 potential articles. Once data have been selected, their analysis may proceed in different ways according to the objective of the review (Crossan and Apaydin, 2010). The screening process here was composed of the following steps: removing duplicated articles, title screening, abstract screening, and full-text screening. The description of the step-by-step development of the review has been omitted for clarity and conciseness, because here the focus is the method used for synthesising the literature reviewed. Following the screening process, 29 studies which matched all the inclusion criteria were included in this review.

Data synthesis. Linking themes across the various core contributions wherever possible and highlighting such links is an important part of the reporting process. Systematic review provides a means for practitioners to use the evidence provided by research to inform their decisions. Within management there is a need to recognise that evidence alone is often insufficient and incomplete, only informing decision-making by bounding available options. A good systematic review should make it easier for the practitioner to understand the research by synthesising the extensive primary research papers from which it was derived. Within management research, a two-stage report might be produced: the first stage would provide full (rough-cut and detailed) descriptive analysis of the field. This is achieved using a very simple set of categories, in order to clarify the main characteristics of the field (methodologies used, classification of countries and industries studied). Researchers may also need to report the findings of a thematic analysis, which consists of synthesising the main outcomes extracted from the literature. Its main purpose is to inform future research and practice (Franco-Santos and Bourne, 2005). In accordance with its objectives, this paper only presents the latter.

1.4. Findings

1.4.1 The logistics process in hospital companies

The concept of logistics in a hospital assumes different meanings, detailed as follows:

- Logistics in the strict sense, or micro logistics, refers to all internal operations of health goods management,

from receipt to delivery on wards. It is the process of strategically managing the procurement, movement and storage of materials, in such a way that the current and future supply flow is maximised through cost-effective fulfillment of orders. Logistics has the aim of making available the right resources in the right place at the right time, with acceptable effort and costs (Elkhuizen et al., 2006; Bensa et al., 2009; Kazemzadeh et al., 2012);

- Supply chain management, often incorrectly used as a synonym for logistics, is a broader concept and refers to internal and external aspects related to logistics, including the relationships with industry (upstream) and with distribution channels (downstream). It consists of the internal chain (patient care units, hospital storage) and the external chain (producers, purchasers, distributors) (Ford and Scanlon 2006; Birk, 2008; Bensa et al., 2009; Rossetti and Liu, 2009; Meijboom et al., 2010; Bhakoo and Chan, 2011; Lee et al., 2011; Kazemzadeh et al., 2012; Smith et al., 2012; Landry and Beaulieu, 2013; AbuKhousa et al., 2014);
- Transport logistics refers to the transport system used to connect the producers of health goods with hospital companies (Bensa et al, 2009);
- Patient logistics includes the activities of planning, organisation and control of the various production areas (operating rooms, areas of hospitalisation, diagnostic services) that the patient goes through during the course of treatment (Bensa et al, 2009).

This paper explores the concept of logistics in the strict sense (i.e. micro-logistics), which considers the following stages (Fig. 1.1) : 1)

health goods procurement and reception, 2) warehouse/pharmacy storage operations, 3) transportation and distribution, 4) management and storage at ward level and 5) delivery to patients (surgeries, patient care) (Cagliano et al., 2007; Bensa et al., 2009).

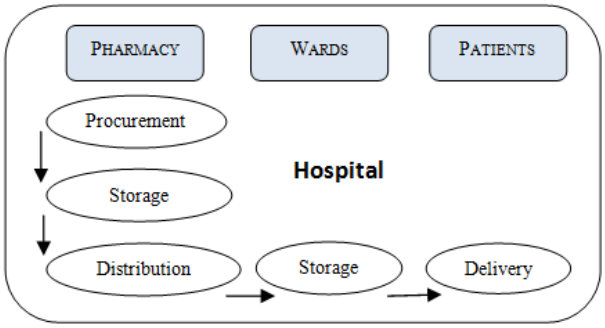

Figure 1.1: Hospital health goods logistics process. (Source: our elaboration)

Logistics, in the strict sense within a hospital, therefore concerns the management of health goods, that is, of all the materials that serve transformation processes, according to pre-specified times, under conditions in which they can be used, at the point where they are required and where the total cost is as low as possible. The increased complexity that characterises the management of logistics flows within the hospital companies is due to different aspects (Landry and Philippe, 2004; Bensa et al., 2009; Ivan Su et al., 2011; Vila-Parrish and Ivy, 2013). These are as follows:

(1) Healthcare companies manage at least three broad categories of goods characterised by markedly different physical, logistical and managerial requirements: drugs in the form of medication in both prepared (for example, an intravenous fluid) and raw drug medications (for example, a powder or solid that requires further processing prior to administration); surgical medical products (medical devices and healthcare material); and economic goods.

(2) This problematises the space needed for storage because stores for health goods are often decentralised and located in multiple locations (health goods warehouses, pharmaceutical warehouses and decentralised ward stores). As such, for the proper functioning of healthcare processes, it is important to know how to coordinate flows of different materials coming from different warehouses located in several different places.

(3) Organisational responsibility for logistics is often fragmented and dispersed among several organisational units with obvious problems of coordination and integration. Multiple units have responsibility for logistics in healthcare organisations including: pharmacies, purchases, logistics, information systems and wards. Intra-organisational collaboration is essential in order to make logistics work in practice.

(4) Logistics has an important impact on the processes of care, that is, on the quality and safety of care provided to patients. This aspect makes it even more difficult to evaluate the performance of a logistics system, as such an evaluation cannot be limited to the traditional measures used in manufacturing companies.

(5) Finally, the complexity of the logistics process results from its variability. In particular, there are three different types of variability which the hospital companies have to oversee in the planning and management of logistics activities: i) clinical – patients have different diseases with different degrees of severity and complexity, and respond in different ways to identical medical treatments; ii) flows – differing access to health facilities and the flow inside them (urgent unscheduled and scheduled access); iii) behaviour – the parties engaged in the provision of health services (mainly doctors and nurses) have different skill levels and different approaches to the same problem (Villa et al., 2007).

Logistics adds value to products by creating place and time utilities, where place utility is the value added to products by making them available in the right place; time utility is the value added by making them available at the right time. The critical objectives of a good logistics include: the improvement of management and staff performance through strong leadership, training, supervision, clear expectation and working conditions; the development of information systems for accurate collection and reporting of data according to when and where it is needed; the enhancement of forecasting and procurement processes; the optimisation of distribution activities; clean, secure, organised storage and good transport systems. This is particularly important in the domain of healthcare services, where efficient provision of these services is expected from the general public. Within the logistics of health goods, the management of pharmaceuticals plays a specific role. It includes all operations ranging from drug prescription to drug administration, therefore it involves two main components: therapy and inventory management, and two main actors: wards and pharmacies. In particular, the drug logistics process can be defined as the task of trying to place the right drugs and medical supplies, in the right quantities and conditions, at the right health service delivery points and at the right time for the right clinic patients and other users, for the right cost (Chikumba, 2010). Logistics management influences the products or services offered: which customers may be reached, the processes with which to reach them, and also where and how they may be reached. The point of departure is the understanding of logistics innovation processes as the redesigning of processes to improve efficiency and effectiveness in relation to sourcing and fulfillment (Ivan Su et al., 2011).

1.4.2 The organisation of the healthcare goods logistics process within a hospital

Innovating and organising the logistics of health goods within a hospital means acting in a coherent and coordinated way across five basic elements (Bensa et al., 2009). The five basic elements are: i) the organisational model, ii) the service operational model, iii) technologies and information systems, iv) the layout and the organisation of space, v) the definition of responsibilities.

The organisational model refers to the choices determining the level of centralisation of logistics functions. In the case of hospitals, health goods management can be fully decentralised at the ward level (supplier-ward direct relationship); it can predict the existence of one or more warehouses inside the hospital, or can be supported by a single inter-company warehouse managed by third parties, upon which different hospitals in a given geographical area converge (for further details, see the following paragraph). The most advanced hospitals at international level are moving towards highly centralised logistics models (i.e. material management departments), which provide a number of advantages. However, especially for drugs, the proximity to the department (i.e. the point of care) is an important aspect for the implementation of high standards of quality and safety through both the reduction of the physical path of goods to the point of care, and the greater involvement of the care professionals.

Having defined the level of centralisation, it is necessary to establish the degree of outsourcing of logistics functions. Especially at international level, outsourcing is now a widespread choice among hospitals, as it enables the pursuit of a number of elements, which, despite their critical aspects (including the choice of external partners

and its associated risks) are considered positive overall. Thus, the role of a centralised supply is diminished in a reengineering environment due to a decreased need for storing goods between the points of delivery by supplier and internal delivery to wards: an efficient hospital would receive items from a supplier to go straight to the appropriate unit. Materials management creates opportunities for applying reengineering principles to healthcare; the relationships with suppliers focus on three areas: i) reducing the number of suppliers; ii) using suppliers that are geographically closer to the hospital; iii) improving relationships with suppliers (Kumar et al., 2008).

After defining the organisational structure of the process, it is necessary to complete a series of operational decisions on various aspects of the management of the process, which constitute the operational model. It includes all the choices concerning: the requests from and the deliveries to the wards, the traceability of goods within the company, stocks and how to manage the goods in the warehouse, the procedures and parameters for re-order, and service standards required by the ward. These are the aspects most affected by the choices of innovation and change in the logistics process.

The management of the logistics process is supported by a series of technologies and information systems that optimise, or otherwise, all phases of the logistics of health goods. Even if there is no doubt that technological innovation will enable significant improvements in efficiency, quality and safety in healthcare logistics, it is nonetheless necessary to emphasise some possible criticalities. First of all, technology is only one of the components of a logistics system, thus in order to obtain the expected results it should be consistent with the other components of the logistics system and with the overall strategic company design. Furthermore, in the implementation of new

technology and information systems, it is important to consider some critical operational aspects, such as the level of integration and standardisation, the presence of training projects for staff involved in the various stages of the process (nursing, medical and administrative), continuous maintenance of the technologies, levels of flexibility of the system and the presence of alternative processes for managing exceptions.

An important component of a logistics system is also represented by the layout and organisation of spaces. There are at least three relevant areas to oversee during the design of the logistics system: the organisation of the warehouse; the layout of the corridors that connect the warehouse to wards and the layout of patient areas. The physical configuration of space is often a constraint for projects of change in hospital logistics. In fact, many technological innovations can only be achieved under certain architectural and physical requirements (some examples are: lengthy corridors, ability to create elevators). Moreover, the choices about the macro-organisational structure have a significant impact on the layout and the organisation of space.

Assuming clarity on the matter of the levers upon which action is needed to change the logistics system, it is less clear who, within hospitals, should take the strategic and operational responsibility to carry out the necessary change projects. Currently, this responsibility is fragmented within different organisational units: the service of pharmacies, logistics offices, purchasing, information systems, healthcare and nursing care direction (Landry and Philippe, 2004). The literature shows a tendency to aggregate under the same organisational unit all the functions involved in the overall process of purchasing and logistics. In the various projects of logistics redesigning, there seems growing consensus on the necessity of giving nurses and pharmacists a

different role from that traditionally attributed. With regard to the role of nurses, there is a strong need to relieve nurses from purely logistical tasks in order to enable them to concentrate more on caring activities. Regarding the role of pharmacists, major reductions in the workload are permitted through the projects of centralisation and outsourcing of warehouses, and the computerisation and automation of various process phases, thus allowing pharmacists to assume an increasingly central role in the policies of clinical governance and supporting clinicians in prescribing activities. In modern hospitals, pharmacists increasingly tend to shed responsibilities more closely logistics-related in order to play an increasingly important role in issues related to clinical governance, such as: i) the verification of prescription correctness; ii) the definition of manual therapy; iii) the decisions in drug treatment; iv) the design and management of information systems to support prescription (Bensa et al., 2009).

1.4.3 Healthcare goods logistics models

As stated above, hospitals are accused of a significant delay in the management of the health goods logistics process, compared to other sectors where the strategic importance of this process has been long recognised. It is widely accepted that a well-designed and well-managed logistics system can ensure a strong competitive advantage difficult to recover, at least in the short term, by competitors. In hospitals, a logistics system is required to supply goods and medications prescribed for each inpatient. There are many varieties in existence throughout the world, but all have the same goal: to ensure that each drug dose administered to each patient is exactly that which was intended by the prescriber. According to the literature, there are

currently three management models for health goods (Bensa et al, 2009; Kumar et al., 2008; Kazemzadeh et al., 2012):

1) *Traditional managing*: a central distribution source – a pharmacy – in every hospital decides what and how to buy according to requests, and delivers goods to the wards, where a standard stock of frequently used goods is available. This is the most widespread system and it entails the highest inventory costs.

2) *Centralised managing*: a unique district or regional center among multiple hospitals which recognises needs, contacts suppliers and oversees inventory management. This centralised management of healthcare goods in a single center or hospital pharmacy replaces the individual hospital pharmacies belonging to the same health organisation.

3) A *logistics operator*: all the physical management and handling of health goods is outsourced, or assigned to a third party logistics company, while relations with suppliers and inventory management with decisions about how and when to order remain in charge of the individual company.

Unlike the case of manufacturing companies, in which the logistics process is a strategic element of management, hospitals are still anchored, in most cases, to the traditional system, because they still hesitate to reduce the inventory level. This traditional system of moving healthcare goods through hospitals presents a series of disadvantages and problems, among which are: i) the high value of provisions accumulated and managed in the central warehouse and in wards, which is related to an increasing risk of goods obsolescence; ii) difficulties encountered by the hospital staff in controlling the wards' consumption; iii) a significant waste of time spent by administrative and medical staff on activities related to the management of health

goods; iv) the high unpredictability of wards' requests and the high risk of error in the phases of associated patient-therapy, manual transcription of prescriptions, preparation and administration of drugs (Cagliano et al., 2007).

1.4.4 Healthcare goods logistics innovation and change

Logistics innovation refers to a complex process which deals with uncertainty in the environment in order to provide solutions for customer needs, achieve efficiency for more effective customer value creation which is expected to result in a positive impact on organisational performance, and find new ways to better organisational processes using new technologies (Lee et al., 2011). Thus, it is worth noting that logistics innovation may well affect all three types of healthcare innovations categorised by Herzlinger (2006) – consumer-focused, technology and business models – allowing reductions in cost and lead time, creation of new operational strategies, provision of consistent quality, and development of flexibility for dealing with rapid changes in the business environment. Furthermore, following Ivan Su et al. (2011), it is possible to distinguish four different types of logistics innovation: products/services (that which is most commonly considered in discussions regarding logistics innovation), processes (new ways of doing things, at the heart of logistics), position (when products or processes are developed into new uses or contexts), and paradigms (for example new business models). Current trends and market pressure on the healthcare industry are making hospital companies seek ways to reduce operating costs (Aptel and Pourjalali, 2001; Cagliano et al., 2007). Furthermore, managers and researchers are trying to improve cost cutting initiatives in the management of healthcare operations, where

the single largest cost after labor is materials. In fact, this sector is under increasing pressure to reduce waste and eliminate unnecessary costs while improving the quality and consistency of patient care. For these reasons, starting from the traditional configuration of the logistics process, literature provides numerous examples of reorganisation projects. Amongst others, Chunning and Kumar (2000) present the application of the *Just In Time* philosophy and Rivard-Royer et al. (2002) detail the *hybrid stockless method*. The healthcare business process reengineering proposed by Kumar et al. (2008) affects all components of its operations, which are repetitive, have reasonably high volume, and deal with tangible items. A virtual chain management, with the creation of a Consolidated Service Center, is proposed by Parker and DeLay (2008). Agwunobi and London (2009) draw from the mass retail system, maintaining a continuous focus on reducing costs. Bensa et al. (2009; 2010) and Boscolo et al. (2011) analyse and explain a multiplicity of case studies regarding the application of Kanban and intelligent carts, computerised or automated cabinets, computerised prescription, unit and personalised dose systems. These innovative systems are not independent, but can be implemented in an integrated and modular way, depending on various factors such as the size of the hospital, its degree of maturity regarding the management of drugs or the hospital's willingness to invest (Aptel and Pourjalali, 2001; Cagliano et al., 2007; Kazemzadeh et al., 2012). Additionally, in accordance with Herzlinger (2006), six forces operating either individually or in combination should be considered when defining a logistics innovation project: industry players, funding, public policy, technology, customers and accountability. Unless the six forces are acknowledged and managed intelligently, any of them can create obstacles to innovation in each of the three areas. Thus, it is important firstly to recognise the six forces

and turn them to our advantage, if possible. If not, it is necessary to work around them, or recognise that there is limited worth in pursuing such a route at the current time (Herzlinger, 2006). It is clear that there are significant margins for intervention in logistics, which in turn would bring significant improvements in efficiency and in the quality and safety of care processes. As the healthcare sector becomes increasingly complex, a key driver of cost and quality is the logistics process, which is critical in ensuring high standards of patient care and providing adequate supplies (Ross and Jayaraman, 2009; Kazemzadeh et al., 2012; Smith et al., 2012). A fundamentally important aspect that emerges from the analysis of literature focused on the logistics process innovation concerns the performance evaluation of innovation projects. It is clear that hospital companies should consider at least four dimensions of analysis to assess the performance of the logistics system: costs, economic and financial benefits, quality of service and safety for patients. At the same cost, a logistics system is better if it leads to economic-financial savings and ensures the highest standards of quality and safety (Bensa et al., 2009; 2010). This particular issue is of such interest that it will be further explained in a later dedicated study.

1.5 Conclusions

This systematic literature review aimed to shed light on the existing body of knowledge related to the healthcare goods logistics process and its innovation within hospitals. The findings have been presented using a thematic analysis, and a number of points emerge. First, the concept of logistics in hospitals assumes different meanings. Our study focused on the concept of micro-logistics, which refers to all internal operations of healthcare goods management, from their receipt to delivery on the

ward. Second, the healthcare goods logistics innovation process requires the definition of five basic elements: the organisational model, the service operational model, technologies and information systems, layout and the organisation of space, the definition of responsibilities. Third, there are currently three models for managing healthcare goods within hospitals: traditional, centralised and logistics. Despite the former still remaining the dominant model adopted, it presents a series of problems and criticalities. Fourth, literature and practice present numerous examples of logistics reorganisation and innovation projects. Finally, performance evaluation of innovation projects requires the measurement of at least four dimensions of analysis. This last crucial aspect has aroused significant interest within the research community, and we decided to examine it in depth in a subsequent work, aimed at understanding the dimensions of analysis and indicators which literature highlights for consideration for the evaluation of innovation projects in the process of healthcare goods logistics. We recognise the limitations to our study. In particular, the databases used and the filtering processes employed may have omitted some relevant research. However, we believe that the rigorous procedure of our systematic review has reduced the probability that the omitted research would have contained information that would critically alter our conclusion. We are hopeful that this broad framework will provide a means to help integrate the wealth of research on logistics innovation in order to advance both research and practice.

Chapter 2

The Performance Measurement Of Changes In The Logistics Of Health Goods: A Theoretical Model

2.1 Abstract

The aim of this paper is to define a measurement system for the evaluation of innovations in the logistics process within hospitals. Driven by the need to contain costs and improve the quality of services provided to patients, hospitals are dealing with the complexities of business process reengineering of their critical processes, among which are the logistics of health goods. 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. 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 its suggestion 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 for the management of hospitals involved in logistics innovation evaluation, which are currently supported with inadequate systems of analysis.

2.2 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 process. Many countries have been developing conceptual frameworks for monitoring, measuring and managing the performance of their healthcare systems to ensure effectiveness, equity, efficiency and quality. From the early 1990s onwards, the process of

corporatisation of healthcare has resulted in the need to introduce performance measurement and management systems in healthcare organisations, overcoming the resistance of professionals and enhancing the skills and capacity of healthcare management. The challenges regarding cost containment and quality improvement required a strong collaboration in the management of organisational processes, so far ruled by rationing of resources and output control, without any real knowledge of the processes and relative performance from which the absorption of resources and quality of service are derived. In particular, the Public Health Service reformation caused the transition from organisations merely oriented to healthcare service delivery, to those oriented to *clinical governance*. This term was used to capture the range of activities required to improve the quality of healthcare services, among which was 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, driving the change are a combination of economic, social and political factors, such as expensive advances in medical technology and increasing life expectancy. These are leading to greater demands being placed upon healthcare services, with hospitals striving to offer better services at lower costs, and the reduction of economic resources. In particular, pharmaceutical expenditure has become more significant in the last few years, and its reduction 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 significant that the proportion of logistics activities on the income statement of a hospital can be around 50% of its total costs. Yet logistics management and innovation are 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 a hospital setting, the logistics of healthcare goods refers to all the activities ranging from the reception of goods within a hospital, until their delivery to the end user(s). The aim is to ensure that the right things are in the right place at the right time, managing both the flows of material and flows of information (Bensa et al., 2009; 2010). The material flow is one of the more complex process in a hospital, because it involves different *activities*: purchasing, inventory management, transportation, returns and expired goods management, annual inventory; and different *actors*: suppliers, hospital pharmacists, nurses and doctors, with corresponding problems of coordination and information sharing. In particular, a modern hospital pharmacy service cannot only comply with 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 optimise processes. Indeed, various hospitals have recently handled a number of ambitious projects in the context of logistics management innovation. Their 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 the 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; furthermore,

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, whilst at the same time incurring higher costs for patients. Consequently, it is of fundamental general interest 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 undertaken on diagnostic and therapeutic techniques, advanced technology implementations and cost sharing. However, there is little or no research about the performance evaluation of individual areas in healthcare, such as logistics. Due to changes in financing modalities of public healthcare, logistics management has to utilise a set of tools and methods capable of assisting with both modeling and 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 mostly by individual contingencies and with the sole intention of replaying a solution successfully tested in other contexts, without a long-term perspective (Boscolo et al., 2011).

In order to address the needs outlined above, this paper aims to contribute to a more complete understanding of the evaluation of healthcare logistics innovation performance by reviewing literature developed in the field of management research. In particular, the following section presents an overview of performance measurement in healthcare and its complexities; following this, there will be an analysis of the evolutionary dynamics in the health goods management models.

The penultimate section is the core of the research, displaying the insights extracted from the literature, which have been articulated and presented in a detailed framework. This work differs from previous examinations of logistics performance measurement in that it uses a broader scope, following implementation of one 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.

2.3 Performance evaluation in healthcare

The concept of *performance* is complex, broad 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 constitutes a main research focus. It is something of a "suitcase word", i.e. a word in which multiple parties place the concepts that suit them, letting the context take care of the definition (Lebas and Euske, 2002). For public sector organisations, performance refers to the ability to meet the expectations of different stakeholders, including users and consumers, citizens and financiers, employees and other organisations. Among these, hospitals have long delayed the introduction of advanced performance evaluation systems; recently, however, the process of corporatisation 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 decentralised 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 organisations to demonstrate that there have been improvements in performance and that objectives have been achieved, particularly with regard to patient safety and quality of care issues. Despite calls for the public sector to import managerial processes and behaviours from the private sector, the adoption of private sector business performance models has been viewed with much scepticism, because these models still focus on the comparison between used resources and achieved goals, profit and process outcomes, and too little on people and the organisational cultures within 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 admittedly low-cost but also, crucially, 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 overall *clinical performance*. Measures over the costs and through the analysis of the processes that cross the organisation 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 performance of hospitals, the *logistics process* is of great significance given that it accounts for around 50% of hospitals' total costs. Furthermore, logistics arises not only as an important aspect in daily operational problems, but also as a strategic opportunity in terms of 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 is certainly the focus of a search for an efficient and effective logistics management, a

structured and systemic analysis, careful to obtain global results sustainable in the medium- to long-term, is fundamental. However, improving performance means first enabling its measurement, and this measurement represents the connection between two moments of the life of each basic process: design, or birth, and improvement, or growth. Nonetheless, logistics and its improvement initiatives do not find a corresponding advancement in the preparation and application of performance evaluation models, which 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 can be identified 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*. These are:

a) *Related to the process to be measured*. 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 as it was rarely identified as a core process of the healthcare system. Over the past two decades, the economic and organisational impact connected with the management of consumer goods in healthcare has changed dramatically and several new realities have led to the implementation of major innovation and change projects (Bensa et al., 2009; 2010). The reorganisation 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 hospitals. Significant results can be achieved only through a new approach to management processes and to physical flows of drugs and medical goods, which were previously organised according to different

perspectives, and characterised by dispersion and fragmentation. The resulting increased complexity of the logistics process within hospitals is also due to different aspects (Pinna et al., 2015): firstly, logistics manages different categories of goods of markedly different physical, logical and managerial requirements (drugs, medical devices, healthcare material and economic goods); secondly, responsibility for organisational logistics is often fragmented and dispersed among numerous organisational units with coordination and integration problems (pharmacy, purchases, logistics, information systems and wards); lastly, logistics has an important impact on the processes of patient care, that is, on the quality and safety of care provided to people.

b) *Related to the specific characteristics of a healthcare service production*. The healthcare sector has historically been distinguished, in terms of operations management, from other sectors. In fact, it is difficult to predict and manage the production plans and the utilisation of production factors, even though several studies have shown that a part of hospital production variability is artificial, and therefore it can be controlled and managed, opening opportunities 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 research into operational efficiency jeopardizes 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, and special storage conditions, which require certain care in the organisation of the various phases of logistics (Boscolo et al., 2011). Managerial complexity in healthcare can be connected to three sub-systems, respectively:

economic, structural and organisational type. The optimisation of the system operation and performance as a whole, therefore, requires interaction between very different disciplines ranging from medicine to economics, management and organisation, as well as including a social dimension. Too much attention on efficiency to the detriment of the others is likely to result in poor quality, low-cost healthcare. In all cases, measurement difficulties result from the scarcity and lack of consistent tools, both nationally and internationally. This criticality suggests the importance of firstly leaning towards composite measures, which can correct the distorting effects caused by taking each measure individually; and secondly, of accepting qualitative methodologies, which can place greater emphasis on the significance of the human component in the process. All this, of course, seems to go well beyond the scope of the "simple" technical measurement of logistics performance, upon which classical systems of evaluation are focused (Vona and Di Paola, 2013).

c) *Related to the public context in which these organisations operate.* There are three main public sector peculiarities that can affect logistics management in a hospital. Firstly, the influence of *politics* on management decisions with respect to both objectives and time horizons, 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 economic, social and environmental aims. Thirdly, the public bureaucratic model, characterised by formal and transparent decision-making processes, designed to ensure competitiveness and equity among suppliers, in some cases can limit management decisions and reduce their impact in terms of efficiency, compared to other sectors. However, public organisations have also some advantages, among

which is an improved propensity to collaborate in a network perspective and the possibility of influencing suppliers (Boscolo et al., 2011).

2.4. Evolutionary dynamics in the management models of health goods

2.4.1 The traditional management system of health goods

The management of the health goods process includes all the operations ranging from prescription to administration to patients and includes two main components: the management of *therapy* and *inventory*. Traditionally, a hospital manages goods in stock, in order to ensure provision in the central pharmacy and 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 do not find a precise location, but are placed in rooms used for storage, sometimes without any codification. Thus, the flow of health goods within the hospital generally involves two major organisational units: the *wards* and the *pharmacy*. They perform a series of interconnected activities: a) at the ward level: the prescription defined 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; and b) at the pharmacy level: all procedures to collect goods from the warehouse, prepare and

distribute them to wards; the under-provision analysis; the management of orders and reminders. 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 an increased 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 high unpredictability of wards' requests and the high risk of error in the phases of 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 corporatisation, which, as mentioned above, has established the introduction of control mechanisms in the National Health System and has contributed to hospitals' economic and financial autonomy. Hence there is a 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 necessitate 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 have hospitals considered the proportion of expenditure on health goods and their management in the balance sheet, recognising the need for change by 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 with innovative systems for managing health goods.

2.4.2 Main innovations in the management of health goods

The following section will detail different innovative solutions in the management of health goods. The first attempt to change and innovate the logistics of health goods in hospitals is experimentation with the *Just in Time* (JIT) philosophy, developed successfully in the manufacturing sector in the 1970s. JIT is based on principles of eliminating wastages from the production process and obtaining high-volume output with the use of minimum stocks of input, also key objectives for a hospital. Another solution which the healthcare sector has trialed is the *Kanban carts* system, which is based on the use of accompanying goods cards which manage orders and inventory movements, according to the *first in first out* (FIFO) logic. Health goods are stored in the warehouse, picked according to a rationale of ward provision replenishment and then distributed through the use of pairs of "twin cabinet carts" containing all goods used by the ward, which transit from pharmacy to wards. A further strategy employed is that of *intelligent carts.* 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 of unloading of goods taken from the ward cabinet and the simultaneous loading to cart. An additional measure is that of a *computerised or automated cabinet,* which consists of cabinets with management software which registers provisions and all movements of goods. It is able to track electronically the operator accessing 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 types of cabinets can contain original packaging of goods and unit doses, and can be connected to reading devices at the patient bed, allowing administrative control via identification bracelets. In addition to the management of therapy, it is also possible to manage the inventory with the automatic issuance of orders to the pharmacy. With a *computerised prescription* system the doctor records the prescription in an appropriate computerised device and it is automatically associated to the patient via an electronic bracelet. This has enabled the transition from manual recording of paper documents to electronic record, with the resulting creation of *computerised medical records* and with the reduction of all errors related to the interpretation of that which was previously manually written. Furthermore, the *unit dose system* has greatly changed inventory management from a physical, technological and informational point of view. It provides division of health goods 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 dispensers. In wards, nurses equipped with barcode readers draw from the dispenser all single dose packages necessary for each administration. Finally, the unit dose evolution is found in the *personalised dose system*, which automates the entire process of managing health through the use of computer technology. Unit doses flow into customised 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 with possible

interactions 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).

2.5 Evaluation systems in the health goods logistics innovation process

2.5.1 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 characterised as being a methodical, transparent and reproducible method of analysing existing literature. It both maps and assesses relevant literature and provides collective insights through the theoretical synthesis of a field. Systematic reviews differ significantly from traditional narrative reviews, because they clearly specify 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. Specifically, "health" and "logistics innovation" or "supply chain innovation" and "evaluation" or "measurement" were used as keywords in a computerised search conducted in a number of top-level management journals within the time range of 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 the method used for synthesising the literature reviewed. Once the search and study selection has been conducted, the information can be analysed either *descriptively* or *thematically*. 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 synthesising 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.

2.5.2 Findings

The aim of a hospital is to provide a high service level to patients whilst respecting a fixed budget, and in order to fulfil such aims, the hospital pursues 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. Strictly from the point of view of managing the logistics process, *logistics effectiveness* is defined as the extent 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 previously agreed goal (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 mentioned, 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 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 an important resource for improving 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 realise its predetermined goals at the expense of a minimum of the organisation'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 organisation: organisations where logistics department have a low, clerical status seems to focus only on operational efficiency measures, while in organisations where the logistics department has a higher status, a 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 merely conveying a need from an internal customer to a supplier and then delivering 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 discussed, the logistics process involves several activities managed by different organisational units, wards and the pharmacy. The objective of the evaluation is therefore to 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 and because it ignores the interactions among these important units and the critical aspects of organisational 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 and safety.

2.5.2.1 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 costs strictly related to the management of the *process* (see Table 2.1).

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.
	Utilisation 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.

Table 2. 1. Cost perspective drivers. Source: our elaboration.

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 of economy of scale due to the adoption of innovation (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 overheads, 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 *utilisation* 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 are the cost of the used *technology* (Bensa et al., 2009; 2010; Boscolo et al., 2011); the *personnel time* spent for manual operations such as internal material request processing, receipt of inbound material, delivery of outbound material, order pickup and external procurement (Bensa et al., 2009; 2010; Boscolo et al., 2011; Ivan Su et al., 2011); the *storage space* occupied which can be addressed 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). The purpose of the measurement is to understand what savings have been obtained with the introduction of logistics innovation, compared to the previous situation, for each dimension of cost considered.

2.5.2.2 Benefits

The second dimension of analysis groups together those indicators that can measure which benefits have been generated by the logistics innovation, both at economic and organisational levels (see Table 2.2).

BENEFITS PERSPECTIVE	DRIVER/INDEX	FORMULATION	AUTHOR
ECONOMIC BENEFITS	*Inventory* *- turnover rate*	The value of inventory. Goods distributed value/ stock average	Bensa et al., 2009; 2010; Boscolo et al., 2011; Ivan Su et al., 2011; Shou

	- *coverage ratio*	value. (Goods in stock average value/consumed goods value)*365 days or *52 weeks.	2013; AbuKhousa et al., 2014.
	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.
ORGANISATIONAL BENEFITS	*Appropriateness*	Healthcare goods' appropriateness of use.	Bensa et al., 2009; 2010; Boscolo et al., 2011.
	Standardisation	Product and process standardisation.	Bensa et al., 2009; 2010; Boscolo et al., 2011.
	Specialisation	Professional specialisation and knowledge management of employees.	Bensa et al., 2009; 2010.
	Suppliers' relationship	A better management of relationship with suppliers.	Bensa et al., 2009; 2010; Boscolo et al., 2011.

Table 2.2 Benefit perspective drivers. 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 high product expiry rates, the

consequentially significant 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 organisations' opportunity costs, that is, money would have otherwise been spent elsewhere within the organisation. Increasing inventory levels depends on a number of factors that healthcare organisations have to consider, among which are: i) proper planning, ii) appropriate inventory level control and, iii) monitoring of budgetary guidelines. Additionally, in an effort to address consumer demands, the hospital needs 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 balances so that hospital budgetary requirements and consumer demands are met (Shou, 2013; AbuKhousa et al., 2014). Logistics performance is therefore evaluable through an analysis of its ability to optimise the flow of goods in order to minimise the value of stocks, releasing financial resources. Thus, with regard to economic benefits, literature provides at least three areas of possible recovery (see Table. 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 can be expressed in either days or weeks, where days is the average value of goods in stock divided by the value of goods consumed multiplied by 365, and weeks is 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, there is 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 organisational benefits, including (as per 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 *standardisation*, through the better involvement of nurses and physicians, as well as technical and administrative personnel; professional *specialisation* 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; and lastly a better management of the *suppliers' relationship*. As with the other logistics performance dimensions, the objective of the measurement is to understand which benefits have been achieved with the introduction of the innovation, compared to the previous situation, for each aspect considered.

2.5.2.3 Quality

Healthcare quality ensures that patients receive safe therapies and that problems are contained and minimised. 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 in turn means security, while *functional* quality relates to how care is delivered. Because most patients are not able to evaluate technical quality unless an adverse event

occurs, patient satisfaction often is based on functional aspects of care and the cost of care.

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	Level of adequate technology.	Wicks and St Clair, 2006.
	Communication	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.
	Workload distribution	Organisation 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.

Table. 2.3 Quality perspective drivers. Source: our elaboration).

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. As such, the quality of the logistics process can be seen as *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 (see Table 2.3): *nursing shortages*, because patients expect prompt interventions from nurses when they place calls, so delays resulting 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 *level of adequate technology* is essential for the improvement of service quality, although high implementation costs and cultural barriers are slowing the adoption of new technology programs in hospitals; *internal communication systems,* which, in addition to enhancing the benefits of physician-patient communication, improve the technical and functional aspects of patient care (Wicks and St Clair, 2006); *frequency of deliveries* in order to maximise 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); *workload distribution,* to which the latest innovations are oriented, with the aim of minimising time-consuming activities and then obtaining 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 inappropriate areas and projects for standardisation of care pathways; 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 achieved with the introduction of innovation compared with the previous situation, for each dimension considered.

2.5.2.4 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 organisations in recent years. The activities considered at highest security risk are those undertaken on the ward, such as the *storage* of health goods (management of cabinets, method of storage in trucks) and all the operations relating to the *administration* of drugs to patients' beds (request transmission, drug therapies transcription).

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.

Table 2.4 Security perspective drivers. Source: our elaboration.

The safety level of the logistics process is measured by the probability of making *errors* in all stages of drug management (Table 2.4). In particular, *error* is defined as any preventable event that may cause the misuse of health goods or damage 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 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; *transcription/interpretation* errors which occur when the prescription, mostly handwritten, is not properly reported, transcribed or interpreted; *therapy preparation* errors are generated by an incorrect formulation or handling of a pharmaceutical product before administration; *distribution* errors include those errors that can occur during the distribution of drugs; *administration* errors are caused by a change in that which the doctor prescribes in the medical record. The purpose of measuring, as discussed, is to understand which improvements have been obtained with the introduction of innovation compared to the previous situation. Note that this area of activities is the main focus of the latest innovations of healthcare logistics, such as distribution in unit dose, computerised cabinets, patient-therapy control systems, automated carts (Wicks and St Clair, 2006; Cagliano et al., 2007; Bensa et al., 2009; 2010; Boscolo et al., 2011).

2.6 Conclusions

The corporatisation process of healthcare companies has focused on the efficient use of resources. This has 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 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 and

clinical perspectives and analysing the logistics process in its interlinked activities. Despite several limitations related to the exploratory nature of the research, it can be of valuable support to the management of hospitals asked to evaluate important innovation projects in the logistics process. The evaluation system presented here will be tested empirically through application to a case study in order to understand which dimensions and related indicators, among those identified, are most significant for the analysis and the measurement of innovations in the logistics process.

Chapter 3

The hospital logistics evaluation systems: a case study

3.1 Abstract

The need to reduce costs and, at the same time, to offer a high level of service to patients requires healthcare companies to rethink healthcare and, when necessary, to redefine its network of activities and business processes. In this context, the reorganisation of the logistics of healthcare goods assumes particular significance as this is a process that has a fundamental impact on the overall performance of a hospital. Given the importance of improving the efficiency of spending and the service quality of care delivered, there is a clear need to support the reorganisation of logistics activities with adequate systems of performance evaluation in order to identify strengths, weaknesses and areas of improvement. The objective of this study is to identify any problems and inefficiencies in the logistics innovation evaluation system adopted by a hospital company and to define possible paths for improvement. The study is undertaken through combining a review of the literature and an empirical exploratory investigation, the latter conducted through qualitative methodology based on a case study. The focus of the case study is the Azienda Ospedaliero Universitaria Cagliari, a hospital affected by the experimentation of new organisational and technological solutions for the management of the healthcare goods logistics process. From the research conducted, and on the basis of a comparison with more complex approaches and measurement systems, it is clear that a logistics performance evaluation system which is based on only a limited set of indicators has evident criticalities. The empirical analysis of this exploratory study needs to be expanded through the analysis of other case studies. However, this study provides suggestions and guidelines for the design of a more articulated and complex tool to monitor the performance of the

healthcare goods logistics process in order to improve the approach and the evaluation system currently adopted by the hospital management. It also contributes to the literature on hospital management through adopting a current research perspective.

3.2 Introduction

The aim of a hospital is to provide an adequate healthcare service to patients while operating within a predetermined budget, and the achievement of this aim is contingent upon a number of objectives involving both process quality (*effectiveness*) and cost containment (*efficiency*). In the pursuit of these goals, healthcare organisations have to redefine and reorganise their system of activities and business processes. Among the critical processes with a strong impact on performance, particular importance is assumed by the logistics of healthcare goods, a process long underestimated and which has only recently been considered of strategic importance in order to improve the efficiency and effectiveness of healthcare services. In particular, the logistics process considered in this analysis covers all the internal logistics activities managed by the hospital pharmacy and the wards, necessary for the reception, storage, distribution and administration of healthcare goods to patients (Bensa et al., 2009; 2010). The performance of the healthcare goods logistics process has received increased attention from both those involved in healthcare management and the academic world in view of the scarcity of resources available for healthcare companies. This has led to the implementation of new organisational, technological and managerial solutions and to the achievement of better results, declined in terms of effectiveness and efficiency of the process. *Effective healthcare logistics* is defined as the

ability of the process to obtain a particular result or standard by selecting a certain approach to management, while *efficient healthcare logistics* identifies the relationship between input used in the process and intermediate and final outputs obtained (Kumar et al., 2005; Jacobs et al., 2006; Cagliano et al., 2007). The effectiveness and efficiency of the logistics process is therefore closely linked to the quality and cost of the service offered (Vona and Paola, 2013; AbuKhousa et al., 2014). In addition, a logistics system creates value when it meets the needs of its users while respecting the rule of "*5 Rs*", that is, providing the right product, in the right quantities, in the right conditions, in the right place and at the right time, ensuring the level of service desired at the lowest possible cost (Bensa et al., 2009; Chikumba, 2010). Considering these objectives, different hospitals have started important projects for the reorganisation of the healthcare goods logistics process. However, despite the increasing popularity of these initiatives and the significant results achieved – both in terms of reducing expenses and improving the quality of services provided – criticalities emerge, particularly regarding the procedures adopted for assessing the efficiency and effectiveness of healthcare logistics. The lack of adequate management tools for the evaluation of the results achieved (i.e. by testing the new solutions) creates difficulties of governing, from the perspective of continuous evolution, the same logistics innovations (Kumar et al., 2005; Bensa et al., 2009 ; 2010; Boscolo et al., 2011). The fundamental purpose of this research arises from the need to link logistics processes to performance measurement and evaluation systems in order to monitor logistics activities, to analyse effective results, to compare these results with the expected objectives and to plan possible actions for improvement. The research is particularly concerned with the need to identify and organise a system of indicators that allow the hospital

management to monitor the performance of healthcare goods logistics processes, to identify any problems and inefficiencies and to define possible actions and improvement paths. The evolution of management studies in the field of measurement and evaluation of performance suggests that, over time, there is a need to widen the traditional assessment tools, generally based on a system of economic and financial indicators, to include competitive, social and environmental dimensions (Wicks and St Clair, 2006; Moxham, 2009; Carbone et al., 2013). This need concerns not only business and enterprise, but, and ever more importantly, also other types of organisations, such as healthcare companies, which are facing the dual challenges of cost containment and making improvements in service quality levels. An approach that focuses solely on measurements of efficiency and cheapness, functional to the achievement of purely business aims, should be integrated with other indicators in order to evaluate the quality and safety of care received by patients. This paper intends to explore the possibility of transferring to the healthcare system, with the necessary adjustments, a multidimensional system of indicators helpful to guide the logistics of healthcare goods towards quantitative and qualitative objectives and towards better results in terms of efficiency, effectiveness, quality and security (Carrus et al, 2015). From a scientific point of view, it intends to contribute to the development of knowledge about performance evaluation of the logistics process in hospitals, which appears to still be limited (Shou, 2013; Vona and Di Paola, 2013). Thus, the case study presented concerns the Azienda Ospedaliero Universitaria Cagliari, an Italian hospital company that is experimenting with innovative solutions for managing the healthcare goods logistics process. The analysis of results obtained demonstrates that the performance of this process is defined in terms of benefits to

the economic, organisational, quality and process safety aspects of the hospital. Economic benefits involve stock reduction and reduced spending on drugs; organisational benefits include increased prescriptive appropriateness; quality benefits involve optimisation of nursing resource management and traceability of the process; and finally, process safety is improved through security implementation and risk management. The paper is structured as follows: the next section presents the methodology used for the research; the third section details the context of the research, namely that of the hospital company Azienda Ospedaliera Universitaria Cagliari; the fourth section describes the solutions adopted by the hospital for managing and organising healthcare goods; section five illustrates the system of indicators used for the evaluation of logistics activities managed by the pharmacy and the wards; section six explains the limitations of this system and proposes an evolution and expansion according to the literature review. Finally, the conclusions of the work are discussed.

3.3 Methodology

The main objective of the work, as previously indicated, is to identify any problems and inefficiencies in the logistics innovation evaluation system adopted by a hospital company and to define possible paths for improvement. As a result of the literature review regarding the evolution of logistics performance evaluation systems in the healthcare sector and in order to satisfy the information needs arising from the objective of the study, it was decided that an empirical exploratory investigation would be conducted through qualitative methodology based on a case study (Yin, 2014). The case study methodology is widely recognised as a fundamental approach to support the analysis of

a complex phenomenon still under development, particularly when its dimensions are not yet fully explained, as in this case. In particular, the selected case concerns the hospital company *Azienda Ospedaliero Universitaria Cagliari*, selected because it is well-recognised as an example of excellence in terms of hospital logistics innovation and because it is one of the first healthcare companies nationwide to have undertaken such a project. The investigation was conducted in three main phases:

I. The first phase covered the analysis, mapping and description of the healthcare goods logistics process managed by the Azienda Ospedaliero Universitaria Cagliari;

II. In the second phase, attention was focussed upon the identification of the indicators used to evaluate the performance of the healthcare goods logistics process managed by the Company;

III. The third phase identified the main limitations of the evaluation system of the logistics process adopted by the hospital and aimed to define possible improvement actions.

The case study methodology has facilitated the use of different strategies for data retrieval: use of scientific literature; company visits to the organisational units involved in the experimentation; analysis of documents and business reports; and interviews with the Administrative Director, the Director of the Pharmacy Service, Pharmacist Managers and Technical and Administrative Staff involved in the experimentation with and management of logistics activities in the pharmacy and in the wards. In particular, in the first phase of mapping the process, the analysis of company documentation, has been integrated into the information given by the Pharmacy Operators and Technical and Administrative Staff, who, during the interviews and the visits to organisational units, defined different phases and process

activities. In the second phase, defining an evaluation system, the analysis of company documentation concerning the experimentation, in particular, has been consolidated and deepened through the interviews with the Administrative Director and the Director of the Pharmacy, as well as through the interviews with Pharmacist Managers and Technical and Administrative Staff. Finally, in the third phase, critical analysis of the evaluation system adopted, the support of the scientific literature has been fundamental.

The use of different data sources has ensured correct data triangulation, that is, convergence between different lines of inquiry. Moreover, in order to ensure the reliability of the research, a formal protocol for the interviews was developed, taking into account the objective of the research and the information obtained from the literature review. The interview protocol contains mainly open-ended questions; face-to-face interviews lasted an average of two hours each, and have been recorded and transcribed in order to isolate all the information useful for the analysis.

3.4 The context of the analysis: the hospital company Azienda Ospedaliero Universitaria Cagliari

The healthcare system of the Sardinia Region (Italy) is undergoing a process of profound change, characterised by the reorganisation of the hospital network, the experimentation with innovative internal and external logistics management methods, as well as the adoption of new technologies for managing information supporting the choices of corporate decision-makers. As regards the reorganisation of logistics and, in particular, of the logistics of healthcare goods, there are many hospital companies that have recently introduced innovative solutions,

with different degrees of complexity. The case presented in this study concerns the hospital company *Azienda Ospedaliero Universitaria Cagliari* (AOUCA) and attention has been particularly focused upon the examination of the performance evaluation system of the internal healthcare goods logistics process, managed by the hospital pharmacy and two wards, where the experimentation of evolved managerial, organisational and technological solutions for the process reorganisation took place. The AOUCA has a complex structure, manifest in three Specialised Hospital Units: the *"San Giovanni di Dio"* hospital and the *"Clinica Odontoiatrica"* clinic in the city of Cagliari, and the *"Policlinico Universitario"* hospital in the city of Monserrato. The Hospital Units include healthcare structures and research centres of excellence and have a combined total of approximately 500 beds. The Company's organisational model envisages that production functions and activities are delegated to the Departments of Integrated Activities (Surgery, Medicine, Maternal and Childhood, Emergency (critical area), Cardiovascular Diseases and Neurology, Diagnosis and Treatment Services, and Images), which in turn are organised into Complex and Simple Structures. The Company management is composed of the General Director, the Medical Director and the Administrative Director, who are in charge of the overall management and legally represent the Company. The other governing bodies of the Company are the Board of Auditors, the Board of Direction and the Direction College. The analysis concerned the hospital pharmacy and two wards which were responsible for experimenting with new ways of managing the healthcare goods logistics process (especially drugs), based on the computerisation and automation of activities. The hospital pharmacy functions to plan, coordinate and provide pharmaceutical care to patients admitted and discharged. This has led, in the year 2014, to the

pharmacy overseeing the management of 40 million euros of healthcare goods (drugs, medical devices and diagnostic products), of which 25 million euros consisted of drugs (among these, 5 million were consumed in the hospital at the bedside and 20 million were dispensed to chronically ill patients). The logistics process managed by the hospital is developed through planning, implementing and controlling the flow and storage of healthcare goods, including the logistics activities handled by wards, until the administration of drugs to patients.

3.5 The logistics process reorganisation

The reorganisation of the healthcare goods logistics process within the AOUCA is determined by a number of factors. One such factor is the controls put in place by the Court of Auditors, which highlighted the continuing growth of healthcare spending and the high volumes of healthcare goods in stock, stressing the need for their more careful management. Another factor is the Company's awareness of the critical issues related to the traditional management of the logistics process, and the need to monitor and make traceable the flows of drugs inside the Hospital Units along their entire route, from distribution to administration to patients, in order to reduce clinical risk and ensure prescriptive appropriateness, together with the efficiency and the effectiveness of pharmacological treatments. To overcome these difficulties, the Company decided to experiment with new ways of managing healthcare goods that allow improvement of the management of information and goods flows along the internal logistics chain. The proposed solution is an integrated hardware and software system of drugs logistics management consisting of computerised and

automated cabinets that optimise the process managed by the pharmacy and the wards (the *BusterSpid* integrated system). The wards selected for the experimentation – *Medicine I* and *Surgery B* – were selected because they were the most important wards for the Company, in terms of number of patients and types of drugs used. Furthermore, they are very different in terms of typology of services provided, thus allowing the verification of the system's versatility and the consonance of the expected results in both the wards. The objectives that the Company intended to achieve with this project were as follows:

- To effectively monitor healthcare goods and control their use;
- To reduce inventory and the physical space necessary for its storage;
- Real-time monitoring of goods stored and their expiry date;
- To promote the efficiency and economy/cheapness of operations relating to goods, services and personnel;
- To redefine the supply chain in order to reduce operating costs;
- To recuperate the time currently used by staff;
- To associate the use of healthcare goods to the patient and/or cost centre;
- To simplify the staff activities in the wards and in the pharmacy;
- To ensure continuity of supply and optimal availability of the products;
- To reduce clinical risk at all stages of the process.

Although the solution proposed for the reorganisation of the logistics management has not altered the existing operating modes in the two wards, it has generated an important process of change. The following section presents the mapping of the new logistics process (Table 3.1):

Organisational Unit	Phase
Pharmacy	1. Receiving of goods 2. Storage of goods 3. Order validation 4. Preparation of drugs carts for wards 5. External transport 6. Delivery to wards
Ward	7. Wards' needs analysis 8. Request for sampling or purchasing – order generation 9. Receipt and storage of healthcare goods 10. Doctor's prescription 11. Prescription transfer to nurses 12. Ward cart organisation 13. Preparation of prescribed drugs and administration to patients

Table 3.1: Phases of the logistics process at the AOUCA. Source: our elaboration

The logistics process begins with the reception of drugs from supplier firms and their control and storage in the warehouse of the pharmacy (*phases 1 and 2*). Pharmacists, having direct access to the treatment of patients by using the software, continuously monitor orders and demands for drugs by the wards, and may modify, evade or reject them (*phase 3*). When checks are completed, the pharmacy operators prepare carts and manage their transport and delivery to the wards (*phases 4, 5 and 6*). The innovative solution experimented with in the ward helps to locate the present stocks of unused drugs, so that they are used before new requests are made to the pharmacy, or they are returned. If there are no stocks, the system automatically generates orders – sampling or purchasing requests – depending on the requirements extrapolated from therapies inserted and minimum stockpiles levels established for each pharmaceutical (*phase 7 and 8*). Once the cart has been received from the pharmacy, nurses follow a detailed procedure for the storage of drugs in the automated cabinets (*phase 9*). Doctors use a web-connected laptop and attribute to patients

the therapies used through prescription software (indicating type of medication, administration schedule, quantity per shift and days of administration). The computerised prescription therefore results in a computerised therapeutic patient card which can be viewed in real time from any device upon which the software is installed, and it can be printed and used in the later phases. Therefore, its transcription in the nursing notebook is no longer needed (*phase 10 and 11*). Nurses draw the drugs according to therapies inserted in the system for each patient and prepare the therapy cart (*phase 12*). For the drugs' administration to patients, nurses use the computer placed in the therapy cart, which allows the bar code scanning of the bracelet worn by the patient and shows the associated therapy to be administered (*phase 13*).

3.6 The system adopted for the evaluation of the logistics performance

With reference to the system of performance evaluation of the logistics process adopted by the AOUCA, the indicators used and the results achieved are presented below (Table 3.2). The system has been defined from the analysis of data from company documents and/or the information provided during the interviews, with reference to the entire period of logistics solution experimentation, i.e. from July 2011 to September 2012.

INDICATOR	DESCRIPTION
1. Ward provision	Number of packages recorded in the ward cabinet (net of those present in the therapy carts); economic value of wards' stocks.
2. Drug consumption	Value of drugs administered to patients in the ward / value of the drugs delivered to the ward; expenditure on the purchase of drugs.
3. Prescriptive	Possibility for the pharmacist to monitor the

appropriateness	management of therapies in the wards.
4. Nursing resource management	Time saved; staff empowerment (making the staff responsible).
5. Traceability	Of drugs, operators and patients.
6. Risk management	Reducing risks related to drug management.

Table 3.2: The logistics performance evaluation system adopted by the AOUCA. Source: our elaboration

Firstly, during the experimentation, the Company has monitored and measured data relating to *ward provisions*, quantified in terms of the number of drugs packages registered in the ward cabinet and net amount of packs present in the carts. In particular, the adopted solution has generated a ward inventory reduction of 72% (Medicine I) and 37% (Surgery B), and a consequential reduction of the economic value of stocks by 35% (Medicine I) and 22 % (Surgery B). The second indicator controlled by the Company was *drug consumption*, quantified by the ratio between the value of pharmaceutical products administered to inpatient wards and the value of the drugs actually delivered to patients on the same wards. The tested solution for the reorganisation of the logistics process has generated a reduction in drug consumption: the ratio between the drugs administered and those delivered approaches, in both wards, to the unit, while spending on the purchase of medicines was reduced by 5% (Medicine I) and 55% (Surgery B). The AOUCA also monitored the *prescriptive appropriateness* in using drugs permitted by the new method of managing the logistics process, during its experimentation. In particular, it was estimated that, with the solution adopted, the pharmacist is able to monitor the ward's management of medications and therapies, limiting discretionary and irrational ward decisions regarding requests and the use of drugs. The system adopted has thus allowed an increase of prescriptive

appropriateness, allowing the pharmacist to implement, through the software, close supervision and coordination of the activities managed by the ward. During the evaluation, the Company has also considered as an indicator of performance the optimisation of *nursing resource management*. This both saves time devoted to logistics activities by nurses, and allows greater staff empowerment, through the use of innovative solutions. The adopted solution has facilitated logistics activities for nurses, who now have more time to devote to patient care; it has also triggered a process of operator empowerment, as operators now participate actively and in a more conscientious manner so that the system of activities can properly close. Another aspect monitored by the AOUCA during the evaluation of the proposed solution regards the *traceability of the process* with reference to 1) the moved good, 2) the operator responsible for moving, and 3) the patient for whom the drug is intended. The innovative solution, which requires a password for access, electronically tracks the access and the operations carried out by the operators, the entire route of the drug and the patient for whom the drug is intended.

The last aspect which the Company supervised in the assessment of the performance of the logistics process is the *reduction of risks* related to the medication management within wards, by automating the process. The solution introduced has resulted in an increase in safety, reducing risks related to the medication management within the wards, through the automation of the entire process.

3.7 Strengths and weaknesses of the evaluation model

The literature review on the evaluation of the performance of the healthcare goods logistics process in a hospital setting defines a system

of indicators grouped into four dimensions of performance: costs, benefits, quality and safety of the process (Carrus et al., 2015).

In particular, one the one hand, the *costs* dimension considers a series of indicators closely linked to healthcare goods (cost of the item purchased, acquisition, inventory management, documentation management, distribution, preparation and utilisation, for orders not met) and to process management (cost for technology, personnel, space occupied, maintenance of spaces and technologies and for any outsourced services).

The *benefits* dimension, on the other hand, includes economic (value of inventory, value of ward provisions and the value of expired inventory) and organisational indicators (prescriptive appropriateness, products and processes standardisation, professional specialisation and knowledge management of employees, and relationship with management of suppliers) necessary for the assessment of logistics performance.

Again, the *quality* dimension expresses the level of satisfaction perceived from end users – patients – and intermediate users – ward operators – of the process in terms of: staff availability, speed and reliability of the answers, appropriate technology, internal communication systems, frequency and precision of deliveries, correspondence between goods ordered and delivered, distribution of the staff workload, accuracy and timeliness of information and traceability of goods.

Finally, the *security* dimension is measured by the probability of making errors in all phases of the process where "error" means any event resulting in damage to the patient due to an incorrect use of a drug, and can be defined in terms of prescription error,

transcription/interpretation, treatment preparation, distribution and administration.

The analysis and comparison between this system of indicators defined by the literature review (Carrus et al., 2015) and the system of indicators used by the AOUCA for monitoring the innovative solution experimented with for the reorganisation of the logistics process (Table 3.3), draws attention to certain considerations.

DIMENSION	DRIVER/INDEX	MONITORED BY THE AOUCA
COSTS		
- FOR THE MANAGEMENT OF GOODS	*Unit cost*	**NO**
	Acquisition costs	**NO**
	Possession costs	**NO**
	Transaction costs	**NO**
	Distribution costs	**NO**
	Operation costs	**NO**
	Utilisation costs	**NO**
	Shortage cost	**NO**
- FOR THE MANAGEMENT OF THE PROCESS	*Technology*	**NO**
	Personnel time	**NO**
	Storage space	**NO**
	Maintenance	**NO**
	Outsourced services	**NO**
BENEFITS		
ECONOMICS	*Inventory*	**NO**
	Ward provisions	***YES***
	Expired inventory	**NO**
ORGANISATIONAL	*Appropriateness*	***YES***
	Standardisation	**NO**
	Specialisation	**NO**
	Suppliers' relationship	**NO**
		+ staff empowerment
QUALITY		
	Nursing shortages	***NO***
	Response	***NO***
	Adequate technology	***NO***

	Communication *Deliveries* *Orders* *Workload distribution* *Information* *Traceability*	***NO*** ***NO*** ***NO*** ***YES*** ***NO*** ***YES (+ operators and patients)***
SECURITY		
	Errors (prescription, transcription/interpretation, therapy preparation, distribution, administration)	***YES***

Table 3.3: Comparison between the evaluation system defined by the literature and that adopted by the AOUCA. Source: our elaboration.

First of all, it is necessary to emphasise that, in general, to enhance the different dimensions of logistics performance it is necessary to use more data and more tools of analysis. It is, in fact, essential to have a complete framework of the upstream profile of costs and benefits before engaging in any proposed reorganisation project of hospital logistics. In the case considered, the costs dimension is not evaluated – none of the indicators defined by the literature have been monitored during the experimentation – while that of the benefits has been poorly evaluated. A greater focus on cost indicators, on the one hand, would certainly have improved the performance evaluation process, because it would have allowed us to more carefully consider what savings have been generated by the innovative solution, both with regard to the handling of goods (thus what savings were generated in terms of cost of purchasing and managing drugs), and the complete management of the process (from savings in costs for the technologies to savings in the used spaces). On the other hand, the benefits dimension, with particular reference to the organisational aspect, is under-developed: indicators such as the standardisation of the process, the level of expertise of the staff and the management of relations with suppliers have not been

monitored, while greater prominence has been given to the reduction of inventories and its associated economic benefits (savings in drug spending). However, an aspect worthy of consideration is the monitoring of the empowerment of the personnel involved in the logistics process, a result not suggested among the literature indicators, and thus one which should be clearly included among the organisational benefits. Secondly, the quality dimension is a key aspect in the evaluation of the performance of any system of activities managed by an organisation. Considering in this case the logistics of healthcare goods as a support process for nursing care services managed by a hospital, it is important to understand how its operation is viewed positively by its end users – patients – and intermediate users – wards. Only by measuring quality indicators is it possible to verify whether the management of the process meets the expectations of its users and therefore if it is moving in the right direction or whether improvements are necessary in order to better meet the needs identified. This cannot only be limited to the monitoring of two indicators (prescriptive appropriateness and traceability, the latter relating not only to goods, as indicated by the literature, but also to operators and patients); moreover, it is currently "estimated" and not carefully evaluated by data collection and observation, as is undertaken for the indicators of economic benefit. Thus, the measurement of quality indicators should take into account the multiple aspects defined by the literature, through periodical analysis, aimed at monitoring all dimensions of quality, from the availability of personnel (which, however, is also linked to the distribution of workloads, so we can in fact assume that it has improved) to characterising the answers given by patients; from the adequacy of technologies and internal communication systems to the characteristics of the deliveries and

orders, and finally the issues related to the given information. All these aspects are considered of fundamental importance in assessing the quality of the logistics process. Thirdly, the issue of security, central in assessing the performance of the logistics process of a hospital, is also here correctly defined in terms of risk management. The criticality observed is due to the fact that, even in this case, this aspect was simply "estimated", and therefore results in missing detections dedicated to understanding how the probability of making errors in all phases of the process is changed. It is, as a result, essential for the actors in charge of the drug logistics governance and thus, for the Pharmacy Service Operators, to define and implement a systematic structure for monitoring, controlling and evaluating the performance of the logistics process, so that it will be able at any time to provide the management with a clear view of the present situation, to detect deviations between planned objectives and results achieved and to allow for the definition of appropriate corrective actions, with more timely and better awareness. This is also in view of the forthcoming implementation of innovative solutions to logistics in all areas of the Company. Therefore, hospital pharmacists should expand, in cooperation with the other organisational actors, criteria and standards of measurement, taking the lead in developing, monitoring, reviewing and improving their procedures for assessing the logistics of drugs. The data and information conveyed through a system of evaluation will constitute valuable support to guide the top management decisions. Data and information can also be shared at all levels of the hospital organisation, with the aim of creating a concrete and real improvement of the internal collaboration, ensuring efficiency, quality and an increased level of service. Only in this way will it be possible to trigger a virtuous cycle that from the monitoring and control of the process leads to the

identification, planning and implementation of concrete actions for improvement.

3.8 Conclusions

The accessibility of the right to health and the value of healthcare services provided depend both on the quality of the healthcare service and on the efficiency of organisational processes that support it. Among such support processes is that of the logistics of healthcare goods, which has a fundamental impact on the performance of a hospital, not only in terms of the costs related to its activities, but also the quality of healthcare services provided to patients. Several hospitals are launching important logistics reorganisation projects in order to pursue the objectives of effectiveness and efficiency. However, these innovative solutions need the support of adequate systems of performance evaluation in order to identify strengths, weaknesses and areas for improvement. The objective of this study was to verify the possibility of transferring a system of multidimensional indicators helpful to guide the logistics of healthcare goods towards quantitative and qualitative objectives and achieve better results in terms of efficiency, effectiveness, quality and safety of care services, thus contributing to the development of knowledge about the evaluation of the performance of the healthcare goods logistics process in hospitals. In this regard, the literature review defines a system of indicators of costs, benefits, quality and safety that a hospital should consider for the evaluation of this process. The analysis of a case study has then allowed the verification of the exact application of this system, documenting how the performance is actually evaluated on the basis of a system of limited indicators, which does not take account of important dimensions of performance

and indicators. As a result of these limitations, the study provides suggestions and guidelines for the definition and implementation of a more articulated and complex tool for measuring the logistics performance of the hospital, in order to better the approach to the evaluation system currently adopted by the hospital management. The evaluation system redefinition should originate in the measurement of the costs dimension, of which no indicator was considered, and the widening of the other dimensions, largely undervalued and monitored through the evaluation of just a few indicators. The revised system may be useful both for this specific hospital organisation as well as to those dedicated to the evaluation of innovative solutions for the reorganisation of the healthcare goods logistics process. Therefore a major redefinition of the assessment tools used is necessary, in the light of the advances registered in scientific research, which show an increasing need for multidimensional approaches considering both the economic and clinical perspectives.

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