The Drug Logistics between Efficiency and Safety for Patients: The Experience of an Italian Region[*]

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Abstract

The objective of this work is to present the latest innovations in the drug distribution processes of hospital companies, which are currently dealing with high inventory and storage costs and fragmented organizational responsibilities. The literature review and the in-depth analysis of a case study support the understanding of the unit dose drug distribution system and the subsequent definition of the practical implications for hospital companies. Starting from the insights offered by the case study, the analysis shows that the unit dose system allows hospitals to improve the patient care quality and reduce costs. The limitations of the research are those related to the theoretical and exploratory nature of the study, but from a practical point of view, the work provides important indications to the management of healthcare companies, which have to innovate their drug distribution systems. This paper analyzes a new and highly topical issue and provides several insights for the competitive development of a fundamental sector.

Keywords
healthcare supply chain management; healthcare innovation; drug logistics process; medical logistics; drug logistics innovation; unit dose system

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1. Introduction

The *Supply Chain* (SC) is a process that includes all the activities from the identification of a customer need through product selection, negotiation with suppliers, payment, storage, distribution and redistribution (Colletti, 1994; Meijboom et al., 2010). The *Supply Chain Management* (SCM) therefore refers to upstream and downstream relationships with suppliers and customers and to solving problems of functional divisions that occur within and between organizations. Thus, there is a need for both *functional specialization* as well as *process orientation* in organizations (Aronsson et al., 2011). The philosophy of SCM is founded on collaboration among SC partners to achieve greater benefits (Andraski, 1998; Stank at al., 2001). SCM was developed initially in the context of manufacturing, but its introduction is beneficial to the healthcare sector, where it shows an important impact on hospital performance, in terms of reducing wastes, preventing medical errors, improving quality of care and service and increasing operational efficiencies (Ford and Scanlon, 2006).

Healthcare SCM is different from SCM in other industries as it handles a diversity of items in widely varying quantities in response to the large number of diagnosis types and procedures (AbuKhousa et al., 2014). It includes the *internal chain* (patient care units, hospital storage) and the *external chain* (producers, purchasers, distributors): hospitals receive products and services from suppliers, and then store and distribute them to each care unit based on the hospital's operation processes. Therefore, healthcare SCM includes *business activities* and *operations* that integrate a continuous, seamless flow of materials and services for healthcare delivery. It is designed to assure a high service level by maximizing the resource allocation, in order to respond effectively and promptly to the patient care needs and thus to achieve *Total Quality Management*. Its implementation has proven to be more complex than other sectors, primarily because it requires the participation of many *different stakeholders*, and also because it is highly influenced by *legislations* and by *healthcare professionals* (Ford and Scanlon, 2006; Bhakoo and Chan, 2011; AbuKhousa et al., 2014). Furthermore, healthcare is a *customer driven service*, which means that customers are an effective part of the process (Rossetti and Liu, 2009; Aronsson et al., 2011). Healthcare SCM processes have three types of flows: *product, information and financial* flows. The product flow or *medical logistics* at one hand includes the supply of pharmaceutical, medical, surgical consumables, medical devices, hygiene consumables, food supplies, equipment and other supplementary products necessaries to support doctors, nurses and of course patients of hospitals. On the other hand, information and financial flows are related to SC decisions for effective product flow and organizational performance improvement (Lee et al., 2011; Shou, 2013).

The aim of this study is to investigate the emerging trends in *pharmaceuticals logistics flow* redesign. Logistics and SC innovation are becoming a highly topical issue in the international research agenda as well as in practice. The reason is that economic and political factors have increased attention to healthcare issues, mainly because of the rapid growth of healthcare costs: the aging of population, the increasing demand for healthcare services, the rising cost of inpatient and outpatient care, professional shortage, new technologies and new drugs will continue to drive up the total healthcare cost. Currently, in the process of pharmaceutical products procurement, healthcare companies accuse relevant gaps compared to other sectors, which can be partly explained by the increased complexity that characterizes the logistics flow management within sanitary companies: hospital companies tend to behave like "individual agents" with their own purchasing offices, a pharmacy and an internal distribution system based on order-delivery processes. Consequently, a large number of transactions sent to different vendors and purchases of large quantities of drugs from individual departments with consequent generation of inventory and storage costs. As a

natural consequence of this diversity of assets to manage, the organizational responsibility of the logistics function is often fragmented and dispersed across multiple organizational units with clear coordination and integration problems. It is clear that there are large areas of intervention in logistics, with possible improvements in efficiency, quality and safety processes. The need for change the way we manage healthcare facilities is due to some fundamental reasons: 1) the process of local health corporatization, which involves the introduction into the national health system of control mechanisms similar to the competitive market models. Hospitals assume managerial and economic-financial autonomy, and they must set their own goals for quality of service and cost management in order to ensure the survival over time; 2) limited resources and a steady growth in spending, hence, the need of a public health rationalization, especially for meeting increasingly quality demands. All this requires 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 (Cagliano et al., 2007). In particular, the *pharmaceutical logistics process* assumes a central position in ensuring the efficient healthcare operational functioning. Since it is crucial for hospital operations, it requires an efficient internal organization; this is extremely difficult given the complexity surrounding pharmaceutical healthcare system: a wide range of products with completely different characteristics to manage, fragmented logistics organizational responsibility, special kind of final customer and also the impact of logistics in the quality of care provided to patients (Cagliano et al., 2007; Bensa et al., 2009). Indeed, a fundamental measure of the quality of a drug distribution system is the *medication errors incidence*, which is any discrepancy between the prescribed and the administered medication (Kazemzadeh et al., 2012). The literature review and an in-depth analysis of an Italian hospital company help us to explain how changes in pharmaceutical logistics flow improve efficiency and reduce costs. Additionally, the study extends to examine whether these efforts were successful and if so, how.

The paper is structured as follows. The second paragraph analyzes the drug logistics process, followed by the third one, which is devoted to the study of drug logistics methods. In the fourth paragraph the Italian case study is presented, and a final conclusion paragraph identifies the main model limitations, the management implications and an indication of possible developments for further research.

2. The pharmaceutical logistics process

Logistics management is the part of SCM that plans, implements and controls the efficient and effective forward and reverse flow and storage of goods, services and related information between the point of origin and the point of consumption in order to meet customers' requirements (Carrus, Pinna, 2011). Broadly speaking, logistics is concerned with getting the right product (or service) to the right place at the right time. Logistics adds value to products by creating utility, and the more the logistics contributes to the value of a product, the more important the logistics management is (Carrus, Pinna, 2011). Place and time utilities are directly affected by the logistics: *place utility* is the value added to a product by making it available for purchase or consumption in the right place, while *time utility* is the value added by making a product available at the right time. The essential objectives of a good logistics include: a) improve management and staff performance through a good leadership, training, supervision, clear expectation and working conditions; b) improve information systems for accurate collects and reports data when and where needed; c) improve forecasting/procurement; d) improve distribution activities, e) clean, secure, organized storage

and f) good transport system (Chikumba, 2010). This is particularly vital in the domain of healthcare services, where efficient provision of these services is expected from the general public. The *pharmaceutical logistics* is the task of trying to place the *right* drugs and medical supplies, in the *right* quantities, in the *right* conditions, at the *right* health service delivery points, at the *right* time, for the *right* patients/users and for the *right* cost (Chikumba, 2010). In particular, the logistics strict view (i.e. the micro-logistics) considers a four-phase process: 1) *drug reception and warehouse/pharmacy operations*, 2) *request and validation*, 3) *transportation*, 4) *ward drug management*. This process includes all operations ranging from the drug prescription to drug administration, therefore it involves two main components, *therapy and inventory management*, and two main actors, *wards and pharmacy* (Cagliano et al., 2007; Bensa et al., 2009). These key logistics steps are supported by a logistics management information system, organizational effort (human resources, training, supervision, procedures and guidelines, equipment), financial resources (budgeting), political leadership (effective policy and legal framework), evaluation and quality monitoring (products and work) (Chikumba, 2010). Managing healthcare logistics means to coordinate four basic elements:

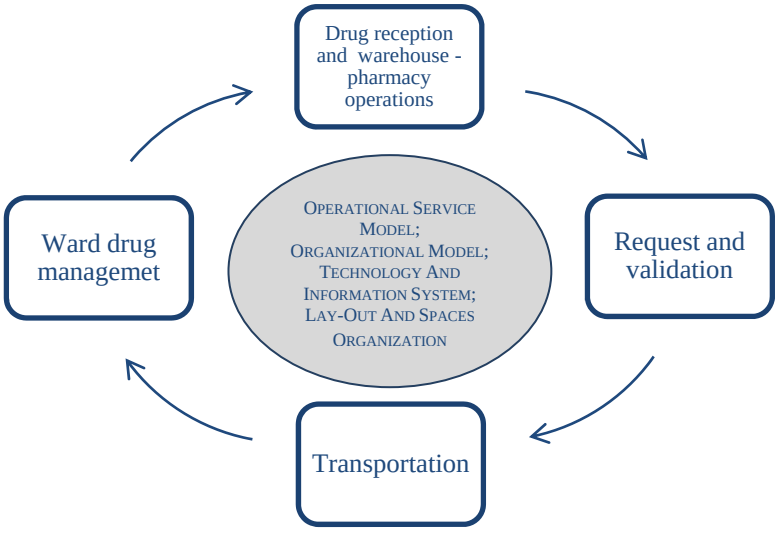
a) *The operational model of service*: it relates to operational decisions on various aspects, from the wards deliveries frequency, to the stocks verification, to the administration of stock goods.

b) *The organizational model*: it refers to two dimensions of choice that determine a significant impact on the overall logistics system: i) the level of logistics functions centralization; ii) the logistics cycle outsourcing degree.

c) *Technology and information system*, capable of optimizing all stages of the logistics.

d) *Lay-out and spaces organization:* the warehouse organization, the lay-out of corridors that connect the warehouse to the wards and the lay-out of patient areas (Bensa et al., 2009).

Fig. 1: The healthcare traditional logistics process.



Source: our adaptation from Bensa et al. (2009)

The increased complexity that characterizes the management of logistics flows within the healthcare companies is linked to different aspects (Bensa et al., 2009):

1. Healthcare companies manage at least *three broad categories of goods* characterized by markedly different physical, logical and managerial requirements: i) drugs, ii) surgical

medical products (medical devices and healthcare material), iii) economic goods. This creates also important problems of space for the storage.
2. *Logistics organizational responsibility* is often fragmented and dispersed among several organizational units with obvious problems of coordination and integration. Multiple units have responsibility for the logistics in healthcare organizations including: i) pharmacy, ii) purchases, iii) logistics, iv) information systems, v) wards.
3. Healthcare companies treat *people*, and this introduces elements of natural variability.
4. Last but not less important point, logistics has an important impact on the processes of care, that is on the quality and safety of care provided to patients. When healthcare actors communicate and share information they are more likely to improve the quality in terms of patient safety, cycle time reduction and operational efficiency (Carr and Pearson, 1999; Kotabe et al., 2003; Prahinski and Benton, 2004; Giunipero, et Al. 2006; Carrus and Pinna, 2011). The safety of patients is the top priority in healthcare, and pharmaceutical managers play a crucial role in protecting their interest. The biggest responsibility of a pharmacutical manager is to ensure that the products purchased for clinical use are good quality ones. This can be achieved by developing a product evaluation system consisting of well-defined parameters to guarantee that only approved products can enter a hospital's stockroom. Additionally, the timely placement factor is probably not as crucial in any other field as it is in healthcare delivery, where delay of a few seconds can cost a life. Therefore, inventory managers have the huge responsibility of making thousands of diverse medical consumables available on time.

3. Pharmaceutical logistics models

Managers and researchers are trying to improve cost cutting initiatives into the healthcare operations management, where the single largest cost after labor is *materials*. In fact, this sector is under increasing pressure in order to reduce wastes, eliminate unnecessary costs while improving the quality and consistency of the patient care. As the healthcare sector becomes increasingly complex, a key driver of cost and quality is the *pharmaceutical logistics process*: the pharmaceutical management is critical in ensuring high standards of patients care and providing adequate supplies (Colletti, 1994; Ross and Jayaraman, 2009; Kazemzadeh et al., 2012; Smith et al., 2012). Healthcare organizations should consider at least four dimensions of analysis to assess the logistics system consequences: 1) management costs; 2) economic and financial benefits; 3) quality of service; 4) safety. 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. With regard to the measurable benefits, there are at least three areas of possible recovery: i) the value of inventories, ii) the value of ward stocks, and iii) the value of expired products. Among the quality standards concurrent multiple items are significant, such as the response ability, the frequency of wards deliveries, the level of goods traceability, etc. Security is certainly one of the dimensions of performance that deserves more attention and that has strongly influenced decisions about the logistics of healthcare companies in recent years. It is precisely in this area of activity that the latest innovations in healthcare logistics are concentrated. Above all, technological innovation in the near future will enable significant improvements in efficiency, quality and safety in healthcare logistics, but it is necessary to emphasize that technology is only one component of a logistics system, and in order to achieve the expected results, it must be consistent with the other components of the logistics system and with the overall corporate strategic plan .

If it is clear what are the levers on which action is needed to change the logistics system, it is less clear who should take responsibility for strategically and operationally carry out the

necessary change projects. This responsibility is actually fragmented within different organizational units: i) the service of pharmacy; ii) the office logistics; iii) purchases; iv) information systems; v) the health wards, and vi) the direction of nursing. The trend seems to be the aggregation under a single organizational unit of all business functions involved in the overall process of purchasing and logistics (Bensa et al., 2009).

According to the literature, there are currently *three management models for drugs*:

1) The *traditional managing:* a central distribution source – pharmacy – in every hospital decides what and how to buy according to requests, and delivers medications to the wards, where it is available a standard stock of frequently prescribed drugs. This is the most spread system and it entails the highest inventory costs.
2) The *centralized managing*: a unique district or regional center among multiple hospitals recognizes the drugs needs, contacts the supplier and deals with medication management.
3) The logistics *operator*: all physical managing drugs movements are given to a third partner who decide how and what to order in the hospital pharmacy.

The main problems related to the traditional system of drug management are related to: the high value of wards fixed deposits; difficulties in controlling the drug consumption at the ward level; the high risk of product obsolescence; the staff time devoted to administrative and pharmaceuticals management; the wards stocks location; unpredictability of requests for wards and the frequency of urgent requests; the risk of failure in the early stages of patient care; preparation, administration and the manual prescriptions transcription from paper medical records to the nursing register paper. These problems create inefficiencies that result, directly or indirectly, in a lower level of service and higher costs for the hospital (Cagliano et al., 2007). For this reason, starting from the traditional healthcare logistics process, literature provides interesting insights in favor of its redefinition. Among others, Chunning and Kumar (2000) display the application of *Just In Time* (JIT) philosophy to the healthcare SCM. Rivard-Royer et al., (2002) present the integration of the internal and external healthcare SC with the *hybrid stockless method.* The healthcare SC business process reengineering proposed by Kumar et al. (2008) affects all components of the external medical SC system. The *virtually chain management* with the creation of a Consolidated Service Center is proposed from Parker and DeLay (2008). Finally, Agwunobi e London (2009), take the cue from the *mass retailer system*, maintaining a continuous focus on reducing costs. It is worth noting that the drug logistics systems redefinition turn around the concepts of *centralization of responsibilities* pertaining to the distribution in a single body among several hospitals and of the implementation of *stockless inventory methods*. Indeed, one possible way to reduce costs of nonvalue-added activities (procurement, storing and inventory management) in hospitals (as well as other organizations) is to develop partnerships with other entities that use or provide those activities. The hospital may reduce costs by using the economies of scale and/or obtaining new resources through partnerships. From here the definition of the other two innovative systems, the centralized managing and the logistics operator, which include these innovative features. However, unlike what has happened in manufacturing companies, in which logistics process is a strategic element of management, the healthcare sector is still anchored, in most cases, to a traditional system because they still hesitate to reduce the inventory level, due to higher lack inventory costs compared to additional inventory ones. Nevertheless, current trends and market pressure on the healthcare industry are making healthcare providers seek ways to reduce operating costs (Aptel and Pourjalali, 2001; Cagliano et al., 2007).

The three management models are combined with innovative *drug distribution systems*, which are not independent, but can be implemented in an integrated and modular way, depending on various aspects such as the size of the hospital, its degree of maturity towards

the management of the drugs or their willingness to invest (Aptel and Pourjalali, 2001; Cagliano et al., 2007; Kazemzadeh et al., 2012):

1) Kanban carts system: a scheduling system for lean and JIT production to control the logistical chain from a production point of view. It was developed at Toyota to find a system for the improvement of a high level of production.
2) Smart carts system: based on RFID, mobile and wi-fi technologies, it guides nurses in the administration of drugs, reducing pharmaceutical expenditure and eliminating the medication risk.
3) Computerized prescription/case history system: it permits the centralization of patient's data collection (clinical history, tests and treatments in progress), their electronic storage and elaboration, in order to help doctors making the best decisions for patients care.
4) *Personalized unit dose system*: a pharmacy-coordinated method of dispensing and controlling medications in organized healthcare settings. It completely changes the traditional process of inventory management, requiring that medicines provided by suppliers to the hospital pharmacy in the pharmaceutical packaging are divided into single-doses, using automatic machines. These packs containing a single dose of drug, labeled with bar codes, are stored in the warehouse locations and drawn on the basis of requests, distributed with the manual or automatic dispenser (Cagliano et al., 2007). The solution described may present some variations, depending on the specific needs of the organization, but a number of distinctive elements are basic to all unit dose systems (Kazemzadeh et al., 2012): 1) medications are contained in single unit packages; 2) they are dispensed in as ready-to-administer form as possible; 3) for most medications, no more than a 24-hour supplier is delivered to or available at the patient-care area at any time. Literature indicates that unit dose systems, with respect to other drug distribution methods, are safer for the patient, more efficient and economical for the organization, and it is a more effective method of utilizing professional resources. More specifically, as the American Society of Hospital Pharmacy (ASHP, 1993) point out, the most relevant advantages are the following:
   1. A reduction in the incidence of medication errors.
   2. A decrease in the total cost of medication-related activities.
   3. A more efficient usage of pharmacy and nursing personnel, allowing for more direct patient-care involvement by pharmacists and nurses.
   4. Improved overall drug control and drug use monitoring.
   5. More accurate patient billings for drugs.
   6. The elimination or minimization of drug credits.
   7. Greater control by the pharmacist over pharmacy workload patterns and staff scheduling.
   8. A reduction in the size of drug inventories located in patient-care areas.
   9. Greater adaptability to computerized and automated procedures

In view of these demonstrated benefits, the American Society of Hospital Pharmacists considers the unit dose system to be an essential part of drug distribution and control systems in organized healthcare settings, in which drug therapy is an integral component of the healthcare delivery. According to the literature, the strategies adopted to reduce medication errors are essentially the following: a) computerized recording of therapy; b) distribution of drugs in unit doses (with different levels of automation); c) active participation of pharmacists in the management of therapy. From an organizational point of view, it is necessary that the wards related to materials, finance, receiving and store-keeping, work in tandem to process effectively the high volume of purchases, receipt and payment transactions that take place at regular intervals. The task of the purchase department is to procure the inventory at lower prices without compromising the quality, by reducing the lead times with the suppliers

through competitive bidding, direct negotiation and group purchasing. An efficient inventory policy should link the supply to the consumption patterns for reducing the overall inventory level. Transactions should be online so that the database gets updated automatically subsequently to each and every issue of material/medicine in order to enhance efficiency (Kazemzadeh et al., 2012). The considerable benefits provided by this innovative solution, as well as the significant changes that it requires, lead us to explore this drug distribution method, addressing the analysis of a case study, presented in the following section.

4. An Italian example of unit dose system implementation

4.1 Research methodology

Because the phenomenon studied here is complex and spread across multiple organizations and in order to assess its peculiarities and criticalities, we chose a single case study approach (Yin, 2014). As Rogers (1998) states: "data about the innovation process are obtained by synthesizing the recallable perceptions of key actors in the innovation process, written records of the organization adopting, and other sources". In Italy there are currently 11 active projects testing the unit dose drug distribution system, involving a total number of approximately 10.000 beds and a total volume of handled materials of about 460 million Euro (*www.gruppogiglio.it*). Among these projects, our case study deals with the Hospital Company*"G. Brotzu"* case, a higher example of elevated specialization in the field of healthcare innovation. The case study methodology allowed us to combine different data collection strategies, and in particular, we analyzed official documentation, regional laws, archives, historical data and organizational plans provided directly by the organization, scientific journals, local newspapers and healthcare magazines.

4.2 Background

The "G. Brotzu" hospital opened in Cagliari in 1982, was transformed into Autonomy Hospital Company by Legislative Decree 502/92, and recognized as Hospital of National importance and high specialization with the Council of Ministers President Decree 08.04.1993. The company is part of the Regional Health Service and, as part of the corporate governance of the Sardinian Region, it is in charge of national importance high performance specialization in some welfare activities. It develops its activities through an open system, careful and sensitive to changes in the general health demand and in the high specialization sector in particular. With over 30.000 patients admitted annually in about 630 beds, the Company adopts the Department as an organizational model aimed at ensuring the integration and shared use of professional, logistics and technology resources of multiple structures related and/or complementary that retain specific autonomy but are aggregated in terms of organization and management, adopting a common code of conducting clinical care, teaching and research. Specifically, the organizational departmental model, ensuring the physical aggregation of multiple and functional structures, is configured as a responsibility center of healthcare, administrative and financial management activities. In this sense, within the Health Department, it is established the *Hygiene and Health Management Activities Department*, which includes, among others, the Complex Structure *Pharmacy and Medicines Management*. It is the health support service of assistance activities, and it has the functions of planning, coordinating and ensuring the pharmaceutical care and all the facilities of the company. It has the responsibility of both clinical and managerial activities, including planning and execution of medical devices and drugs procurement procedures, as well as their procurement and use rationalization. Additionally, it makes prescription pharmaceutical

analysis about pertinence, guidelines and scientific evidence respect, and finally, it is protagonist in the implementation of the drug distribution through the latest technologies.

4.3 Discussion

The *"project of pharmaceutical goods automation, unit dose drug implementation and customized therapy for the traceability of medical devices"*, started at the Brotzu Hospital Company in 2002. The Company distributes the medication in unit dose for personalized therapies at approximately 200 hospitalized patients, previously with manual activities, then with special machinery ones. Needs analysis indicates a quantity of unit doses of approximately 950.000 on an annual basis. The objectives of the project are various, and they are classified in three categories: 1) clinical, 2) economic and logistics and 3) administrative (Tab. 1). The project aims a general reengineering of drug prescription and administration processes, the realization of the unit dose and of the personalized and controlled therapy, together with a suitable system for the traceability of medical devices that simplify the loading and unloading processes both in the pharmacy and in the Company.

Table 1: Unit dose implementation project objectives

Clinical objectives	Economic and logistics objectives	Administrative objectives
Reduce errors of transcription and interpretation; Greater control on therapeutic profiles and drugs appropriateness; Decision support to the prescription; Medication errors and related adverse events reduction; Prescriptions and therapies monitoring and traceability; Ability to integrate data related to treatment within the medical record; Optimization of human resources commitment (in particular the recovery of nursing time).	Optimization of pharmaceutical expenditure; Reduction of ward and department inventories; Reduction / elimination of expired drugs; Drugs traceability; Medical Devices traceability; Logistics optimization.	Quantification of pharmaceutical expenditure; Computerized management of stocks, even at the departmental level; Consumption monitoring; Simplification of management procedures.

Source: our elaboration.

This basic assumptions of the project are considered essentials:

a. the total traceability of medicines requirements and administration;
b. the unit dosage utilization for the largest possible number of pharmaceuticals;
c. the support services implementation, quantitatively and qualitatively adapted to the characteristics of innovation introduced by the supplies;
d. the unique architecture of the project, able to express a coherent system of technologies and services, integrated into the organizational and informational aspects.

The project involves the replacement of technology currently present in the pharmacy with a next-generation technology that enables greater efficiency, speed and safety in the production of drugs in unit dose. The management model involves the use of ward automated cabinets and of centralized pharmacy for the personalized therapy preparation. Automatic cabinets are located within some operational units identified on the basis of logisticsal, economic and administrative considerations (presence of appropriate spaces for the placement of the cabinet, the daily average consumption of drugs, etc.); additional cabinets are placed in the pharmacy in order to assist staff dedicated to the preparation of therapies for wards missing the dedicated cabinet. The project implementation is entrusted to an agency contract, but Hospital Pharmacy remains responsible about control, acceptance, validation and use of all the activities made by the contractor. The hospital staff and, in particular, the pharmacy, remain responsible about the packaging materials logistics (receipt, storage, handling) and

supervision, together with the validation and control of all activities carried out by the contractor. The wards unit dose drugs delivery is required at the contractor's personnel, while it remains in charge of ward nursing the unit dose medications administration once delivered (in particular storage operations within technologies).

4.3.1 Before the implementation

Traditionally, the pharmaceutical flow within the hospital involves different actors operating in different sectors which play a number of activities interacting with each other (Fig. 2)

Fig. 2: the traditional pharmaceutical flow at Brotzu hospital

PHASE	DOCTORS	HEAD NURSE	NURSES	PHARMACY MANAGER	PHARMACY STAFF
1	Definition of the therapy				
2		Cart preparation			
3		Preparation and administration of drugs prescribed to patients by nurses			
4		Analysis of the needs of the department			
5		Withdrawal or purchase request at the pharmacy			
6				Analyze requests and authorizes companies to engage in picking	
7					Check for the presence of codes and wondered if any of expired drugs
8					Preparation of carts with items ordered from departments
9				Verification of the correctness and signing the bill of delivery	
10					Transport of carts to the wards

Source: our elaboration

The process starts with the doctor therapy prescription (type of drug, dose and time of administration) to be administered to the patient (Phase 1). This prescription is then manually transmitted to nurses who then write it down on the nursing register. The head nurses (or the nurses) consult the patient register and check the ward cart for the presence of drugs needed for the next round of administration. In case of medicines missing, they recuperate them in the ward warehouse. The ward cart replenishment can be done simultaneously with the prescription or at the end of the administration round. Once identified each patient, visually and by looking at the number of room/bed and the name, nurses consult its treatment in the nursing register and identifies the drug by reading the name on the package. If the medicine is not present on the basket, they provide for recovering it. The administration and its outcome are finally written down on paper (Phases 2 and 3).

With frequency varying from department to department (from once a day to once a week) and independently by prescription/administration, the head nurses or administrative personnel control the quantity of drugs in the ward warehouse to determine the volumes to be taken to the pharmacy. This is one of the most important phases of the drug logistics process. However, in this phase special techniques are not used because each operator usually relies on his knowledge and experience. Always with variable frequency, nurses carry out the inventory of materials in the ward warehouse and in the ward cart: counting, sorting,

packaging, elimination of any overdue materials. This operation is usually carried out during the night shift (Phase 4). The needs analysis output is the list of items to be requested. For encoded material, which is already present at the central warehouse, the employee makes a *withdrawal request* for the required amount, while for new material not found in the register a *purchase request* is made with an extended item description with detailed technical characteristics. Both requests are mostly drawn on paper and transferred directly or by computer to the pharmacy (Phase 5).

At this point the pharmacist analyzes requests and authorizes operators to perform the picking (Phase 6), and the warehouse personnel verify the presence of the codes wondered and any expired medicines (Phase 7): drug packages are collected from the pharmacy according to the picking lists and ward carts are set up with items ordered from each department (Phase 8). Next, the unloading amount of drugs is needed: the material is downloaded from the central warehouse and simultaneously uploaded to the periphery one. At the end of collection procedures, the pharmacist verifies the correctness and sign the bill of delivery (Phase 9). Finally, warehouse personnel but also sometimes department one transports carts with boxes of medicines to destination wards (Phase 10).

Periodically, based on sampling, measurement units and class value of items in central warehouse, the pharmacy performs a consumption analysis by updating the parameters of the minimum stock. The comparison of these parameters with the inventoried material in stock identifies the under-provisions that must be ordered to suppliers. If an ordered material is in late delivery, the pharmacy issues a reminder to the supplier. This procurement procedure through the central pharmacy is sometimes used only for ordinary products, namely those of wide use and economic value content. The so-called “special products”, rarely used and often of high-value, can be ordered directly from suppliers departments. In this situation, the pharmacy is responsible only for their transfer. Once the drugs arrive in the ward, head nurse signs for acceptance on the bill of delivery, and then proceed to their storage. The drug packs order criteria are completely discretionary and may vary from department to department, for example, the alphabetical order with the growing expiry date.

The process just described allows us to highlight some critical aspects of the traditional system of pharmaceutical management (Tab. 2).

Table 2: Unit traditional distribution criticalities.

Criticalities
High value of ward fixed deposits
Failure to check the actual ward consumption
Lack of methodologies and tools available to the hospital staff for the ward consumption estimation (management of orders is based on experience)
High risk of product obsolescence (managing deadlines is difficult)
High time spent by administrative and healthcare staff for pharmaceutical management (requirements analysis, receipt and storage, management of packaging and packaging needs of frequent inventories, etc.).
Location of ward stocks (often do not directly feeds a shelf, but it is left to the nurse, within a box, the set of requests processed. Even in cases where there is a shelf, the criteria for his coverage are discretionary)
Unpredictability of requests for wards
High frequency of urgent requests
Risk of error in the early stages of association and patient care, preparation and administration of the drug (all controls are visual and left to nurses)
Manual transcription of prescriptions from paper medical records to the nursing register paper (loss of information risk)

Source: our adaptation from Cagliano et al.(2007).

In particular, it is emphasized that the stocks held in the central and ward stores are too large compared to those needed to prevent stock breakages. This practice creates inefficiencies that result, directly or indirectly, in a lower level of service and higher costs for the hospital. Unfortunately, very often those involved in the management of the warehouses are not aware of the economic performance of the structure. Another aspect worthy of consideration is the excessive involvement of nurses in activities not related to their profession: the inventory control department, the preparation of requests to the pharmacy, the transport of material from the warehouse to the department and its storage. All this reduces the time available for the treatment and care of patients and adversely affect the level of nursing service.

4.3.2 After the implementation

The unit dose system adoption we present in this study (Fig. 3) required particularly significant organizational changes with regard to the physical and informative flows management.

Fig. 3: The unit dose flow at Brotzu hospital

PHASE	DOCTORS	HEAD NURSE	NURSES	PHARMACY MANAGER	PHARMACY STAFF
1	Computerized prescription				
2				Reception and control of therapies	
3					Unit dose and personalized therapies preparation
4					Cart preparation
5				Checking and signing	
6		Computerized cabinet: reception of the box with therapy for 24 hours divided by sectors			
7		Therapy administered to the patient through the use of barcode			

Source: our elaboration

The doctor, during the tour visit, take notes on paper, then goes to a ward terminal and personally types the demand for care, which is performed on the active principle (Phase 1). After the acceptance, drugs are delivered to the pharmacy (Phase 2): here two-dimensional bar codes are printed, placed on sacks of unit doses, on products that have a not legible commercial code or on individual doses that don't have the commercial code on the individual blister (Phase 3). After the cart preparation (Phase 4), a general check and the signature by the pharmacy manager take place (Phase 5). Unit doses are than delivered to the wards semi-automatic dispenser cabinets with drawers, containing 24 hours of spare (Phase 6). Each nurse is dedicated to 3-5 patients and to read doctor's prescription is equipped with: a laptop and a barcodes reader connected in a wireless network and a personal ward trolley equipped with a personal computer through which reads dosing and print labels. Then, to access the dispenser, the nurse inserts the personal code and retrieves products from specific drawers that open automatically. Drugs prescribed to patient with bracelet are then administered to him, which are automatically downloaded from the inventory (Phase 7).

The project required structural and plant design work for the system functionality (wireless network, machineries installation, etc.), the purchase of equipment for automatic dispensing, the hardware (tablets and palmtops for administration control) and software (prescription program, administration, warehouse), as well as for patient identification bracelets with printing serialized barcodes. Briefly, the drugs administration is regulated by a computerized system that collects the therapeutic prescriptions, written by the physician for each patient through the tablet linked to the network with the pharmacy. In the pharmacy, a specific machinery provides for the automatic packaging of medications in single-doses and for the composition of rings containing the personalized therapy of the patient, labeling the box with patient vital statistics and time of administration, and reporting data to a barcode. Finally, packages are sent to the ward in the predetermined time on a daily basis and for a period of 24-hour coverage: here, before proceeding to the administration, nursing staff cross-check therapy – patient – administration time – personnel carrying out the administration, identifying the patient by reading the barcode bracelet and noting the coincidence of the data indicated on the package containing the personalized therapy thanks to a palmtop reader with infrared connected to the hospital network. This system has allowed the Brotzu Company to obtain considerable advantages in terms of:

1) Ward stocks reductions, resulting in reduced inventory of warehouse pharmacy;
2) Reduction of medicines cabinet (dispenser) management (the dispensers are the default locations for drug);
3) Reduction of the likelihood of errors and simplification of the overall process of ward carts preparation and medicines administration (barcode readers support nurses in the drug recognition).

5. Conclusions and directions for future research

The present work aimed to investigate the emerging trends in *pharmaceuticals logistics flow* redesign by focusing on the unit dose distribution system. We presented an Italian case study to explain how this innovative method improve efficiency and reduce costs. The hospitals corporatization process has focus the attention on the efficient use of resources, rising the attention on the need to reconfigure the healthcare logistics and, in particular, the pharmaceuticals management, whose importance is fundamental to the provision of care services to patients. While the manufacturing sector has always been at the forefront of experimental approaches to rationalizing inventory and material flow, the healthcare sector has long remained anchored in traditional approaches based on maintaining high quantities of products in stock to avoid the risk of stock out, and in poorly formalized and automated stages. Although nowadays many hospitals continue to adopt this scheme for the drug flow management, some are actually applying industrial production management principles, first of all those relating to the JIT philosophy, in order to overcome the limitations of such an approach. Assessing the state of the art in Italy and abroad, it appears many innovative systems: from Kanban carts to intelligent carts, until the personalized and unit dose system. The hospitals logistics re-engineering development will be increasingly based on the integrated implementation of these solutions, depending on various aspects, such as the size of the hospital, its degree of maturity towards the drug management or their willingness to invest.

Among these innovative ways of managing drugs, the case study we have presented in this study analyzes a unit dose distribution system implementation. This system requires that medicines are divided into single-patient-personalized doses, with a significant elimination or minimization of drug inventories and a reduction in the incidence of medication errors. In

particular, this work has identified some progressive levels of logistic redefinition: from the use of automated carts shelves to supply wards, up to the realization of an effective flow where the request to the central pharmacy is directly derived from the requirements and no longer by subjective assessments of head nurses. Each of these stages is supported by an increasing level of automation and computerization, and the jointly application of different tools for the pharmaceutical flows optimization allows hospitals to create synergies between its benefits and overcome their weaknesses, achieving cost reductions and increased patient care quality. The work, far from being definitive, represents a first attempt to explore this highly topical issue and it is therefore desirable that future research destinies more and more attention to it, focusing on the latest possibilities offered by Information and Communication Technology in favour of patient quality care.

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