Journal of Theoretical and Applied Electronic Commerce Research
ISSN 0718–1876 Electronic Version
VOL 4 / ISSUE 1 / APRIL 2009 / 23-38

This paper is available online at
www.jtaer.com
DOI: 10.4067/S0718-18762009000100004

E-Procurement in Hospital Pharmacies: An Exploratory Multi-Case Study from Switzerland

Tobias Mettler[1] and Peter Rohner[2]

University of St. Gallen, Institute of Information Management,
[1] tobias.mettler@unisg.ch, [2] peter.rohner@unisg.ch

Received 14 August 2008; received in revised form 14 November 2008; accepted 28 January 2009

Abstract

Structural changes and increasing market dynamics in the health care sector intensify the hospitals' needs for cost-savings and process optimization. The adoption of new information and communication technology (ICT) is thereby seen as opportunity to improve not only efficiency and effectiveness but also the quality of health services. As costs for drugs continuously increase, especially hospital pharmacies will be in need of acquiring expertise and technology in order to enhance the sourcing processes. The diffusion of e-procurement is however slow in this area. To investigate why hospital pharmacies only have a modest adoption rate of e-procurement, case studies of three distinct Swiss hospitals with differing organizational structure and automation degrees are presented. It will be shown that technological as well as organizational change is needed in order to efficiently use e-procurement in future.

Key words: Business Networking, E-Business, E-Health, E-Procurement, Health Care, Supplier Relationship Management

Journal of Theoretical and Applied Electronic Commerce Research
ISSN 0718–1876 Electronic Version
VOL 4 / ISSUE 1 / APRIL 2009 / 23-38

This paper is available online at
www.jtaer.com
DOI: 10.4067/S0718-18762009000100004

1 Introduction

In industries characterized by intense competition, the effects of globalization, fragmentation of markets and new technological advance, e.g. in information transmission and information processing, had a tremendous impact on the division of labor. This led to higher specialization and standardization of service components and to shorter processes and lower costs [19].

Up to now, the health care sector has only seen the beginnings of this development. In Switzerland, as in many other industrialized countries, the health care market is still marked by monolithic structures and inertia [41]. The fact that the Swiss health care market differs in structure from most other sectors is attributable to the high level of regulation which can hinder or prevent innovation, the high proportion of government investment and the associated low pressure in respect of effectiveness and efficiency, the lack of orientation towards patient benefits and the widely differing interests of the individual players [33]. However, more recent advancements such as the introduction of fixing rates for patient treatment (e.g. Swiss-DRG, TARMED) nonetheless provide a clear indication that the pressure to achieve effectiveness and efficiency is set to increase significantly.

This development towards better cost consciousness and process outcome will also affect the procurement activities of hospital's pharmacies [32]. The adoption of e-procurement saves the costs of the preparation and transmission of paper purchase requests and invoices and enables ordering systems to be tied directly to production systems, thus eliminating costly, time-consuming errors from manual data entry [7]. A study from the neighboring country Germany revealed that 38 percent of the German hospitals already implemented an electronic purchasing order and 35 percent an electronic invoice [20]. For Switzerland no such evidence exists so far, but the adoption rate should be more or less at the same level. Nevertheless, this ratio seems to be marginal when comparing with the aviation industry where 85 percent of the organizations actively use e-procurement in day-to-day business. Hence, approximately 35 to 40 percent of hospital supply-related costs are devoted to handling and processing material and purchasing orders as compared to other industries where it is less than 10 percent [21].

As in most Swiss hospitals the pharmacists are in charge of materials supply (or at least in parts), special attention has to be given to them when e-procurement is studied in the context of health care. On the one hand, the hospital pharmacy acts as an interface between the hospital and the many external stakeholders involved in the supply of drugs (left side of figure 1). On the other hand, it serves as a focal point for a lot of internal departments (right side of figure 1). For instance, the pharmacy is not only responsible for drugs supply but also offers consultancy services to clinics, prepares medical devices for the laboratory, provides additional information for the patient administration, the financial department and so forth. Having this gatekeeper role, the hospital pharmacy is supposed to be an important opinion leader when new technologies for enhancing procurement activities are implemented, especially when it is assumed that up to 60 per cent of their valuable labor time gets lost due to manual processing of transactions [2].

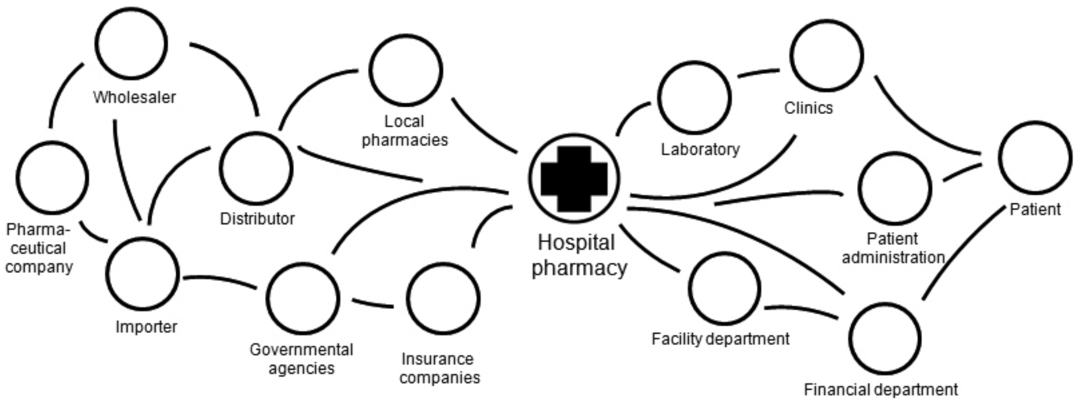


Figure 1: Hospital Pharmacy as Interesting Case for Studying E-Procurement

In order to better understand why the diffusion of e-procurement in hospitals is so slow, this contribution aims at exploring and discussing the current state of adoption of different technologies used for supply-related activities in hospital pharmacies. We do this by applying Roger's theory on the diffusion of innovations [42] to our empirical findings. Thereby not only contemporary weaknesses are identified but also valuable insights regarding possible fields of application for new technologies are given. Thus, this paper is equally addressed to e-commerce researchers and health care practitioners who are generally interested in the adoption and diffusion of technologies, and particularly in the automation and standardization of processes within hospitals. In doing so, the paper is organized as follows. After this introduction, we give a brief overview of different information systems used in hospital pharmacies. Then, our research procedure, the 'cases', and the analytical framework to analyze these cases are described. The section that follows presents the discussion of the results and the implication of the analysis. Finally, we present some concluding remarks and offer some suggestions for future research endeavors.

Journal of Theoretical and Applied Electronic Commerce Research
ISSN 0718–1876 Electronic Version
VOL 4 / ISSUE 1 / APRIL 2009 / 23-38

This paper is available online at
www.jtaer.com
DOI: 10.4067/S0718-18762009000100004

2 An Overview of Information Systems in Hospital Pharmacies

As illustrated above, a hospital pharmacy cultivates a multitude of relationships to internal and external stakeholders with distinct needs and abilities (e.g. either having a medical or an administrative background). Therefore the pharmacy department is often confronted with a plethora of different information systems. We distinguish three different types of applications designed to meet the needs of the pharmacy department: (1) medical applications which aim at storing, retrieving, processing and analyzing information for the purpose of prescribing, dispensing, and administering of pharmaceutical products, (2) administrative applications which are used for processing business-related information (e.g. purchasing orders, billing), and enabling technologies such as Radio Frequency Identification (RFID) or Bar Coding Systems that can be applied for supporting both, medical and administrative activities. A brief description of the applications typically supporting hospital pharmacies is given in table 1.

Table 1: Applications Used in Hospital Pharmacies

Type	**Description**
Medical applications	*Clinical Information Systems (CIS)* also referred to as *Hospital Information Systems (HIS)* are used to "collect, store, process, retrieve, and communicate patient care and administrative information for all hospital-affiliated activities and to satisfy the functional requirements of all authorized users" [53]. They can be composed of one or a few software components with specialty-specific extensions as well as of a large variety of sub-systems in medical specialties (e.g. Pharmacy Information System or Laboratory Information System). Typically, the Electronic Medical Record (EMR) takes a center stage within a CIS, providing for example information on allergy history, medications in use, diagnoses, weight, and age appropriate to the medication [10].
	Pharmacy Information Systems (PIS) are especially designed for helping pharmacists to make decisions about patient drug therapies. Their emphasis lies on reducing medical errors, improving communications between nurses and the pharmacy department, and providing integration and interoperability in closed-loop medication administration [15]. Key features are for example prescription management (e.g. matching of prescriptions to available pharmaceutical products), clinical screening (e.g. monitoring of drug interactions and other medication-related complications, creation of patient drug profiles), inventory management (e.g. control of stock), and reporting (e.g. generation of reports concerning the medication usage and the costs of the purchased drugs) [6]. Like in the case of a CIS, they can be composed of one or a several software components (e.g. Computerized Physician Order Entry or Automated Dispensing System).
	Computerized Physician Order Entry (CPOE) is an electronic ordering system with a proven record of reducing medication errors and patient hospital stays [1, 5, 29]. It is assumed to reduce up to 80 percent of medication errors, and 50 percent of errors with serious potential patient harm [3]. The main focus of CPOE is therefore on the reduction of prescribing errors by providing physicians or other types of prescribers with various decision support functionalities (e.g. interaction checking, automatic dosing alerts). Thus, CPOE can be seen as important technical interface between the pharmacist and the medical and nursing staff.
	Automated Dispensing Systems (ADS) complement CPOE in that not only the prescription but also the administration of drugs is automated. Its main purpose is thus to "free up pharmacists' time from dispensing drugs by allowing drug dispensing to be done right at the point of care by nurses" [10]. A physical part of ADS typically consists of cabinets with drawers containing medications. The cabinet is equipped with guiding lights and directs the nurse to the correct automated drawer containing the medication.
	Unit Dose Dispensing Systems (UDDS) are other means for automating the administration of drugs. Whereas ADS is applied at the point of care, UDDS are used for the preparation of drugs in the pharmacy department (typically for non-fluid medicines such as pills). For this purpose the required drug doses are individually prepared, packaged and labeled [48]. Most significant advantages resulting from an UDDS are for example the central location of drugs (the size of the ward stock is reduced), maintained drug identity (each dose is identified according to name, strength, and the patient for which it is intended), and a reduction of the preparation time (the dose is simply removed from the medication cart, opened, and administered directly to the patient) [35].
Administrative	*Administrative Information Systems (AIS)* typically are implemented for the handling of

Applications	admissions, discharges and transfers of patients, scheduling of resource plans, and for the accounting of the services rendered by the pharmacy department [10]. They provide all necessary functionalities to communicate with the administration departments of a hospital.
	Operational Supplier Relationship Management Systems (oSRM) are used for ordering, invoice verification, payment, and concluding agreements with suppliers. Typical examples of operational SRM are plan-driven purchasing tools, desktop purchasing tools, electronic catalogues, e-payment, supplier self-service, and supplier portals. As a lot of a pharmacist's valuable labor time is lost because of paper shuffling, operational SRM can help to increase the flexibility and responsiveness of the pharmacy department and to reduce cost [23].
	Collaborative Supplier Relationship Management Systems (cSRM) are used to improve the quality of supplier collaboration, and to increase its performance and reliability. E-collaboration tools (e.g. collaborative forecasting and planning), e-contract management tools, e-auctions, e-tendering, and e-RFx tools (e.g. electronic request for information, quotation, and proposal) fall into this category.
	Analytical Supplier Relationship Management Systems (aSRM) aim at storing, analyzing, and applying knowledge about suppliers and personnel dedicated to manage the supplier's relationship. Exemplary applications are business intelligence, on-line analytical processing, statistical tools, data warehousing, and data mining [34]. As the pharmaceutical market is becoming more and more complex, aSRM is particularly helpful for pharmacists for analyzing the drugs market in order to safekeeping the materials supply.
Enabling technologies	*Bar Coding Systems* can be used for a multiplicity of medical and administrative use cases. Possible applications are for example, patient identification (is the right patient at the right place) [26], medication control (has the right patient received the right drugs) [50], and inventory control (are the right drugs in the right repository). However, it is restricted today in that only 35 percent of the medicaments are labeled by a bar code yet [10]. Nevertheless, it is assumed that a 50 percent reduction in medication errors is achieved these days when using bar code systems as against to manually administering drugs [50].
	Radio Frequency Identification (RFID) is based upon storing and remotely retrieving data using so called RFID tags or transponders. As opposed to bar coding systems where the reading of data often requires human interaction (e.g. scanning the bar code with a specific reader), RFID receives and transmits signals automatically. Therefore RFID is increasingly used in hospitals for locating patients, staff and assets, drug anti-counterfeiting or medication error prevention [22]. However, possible interference with other medical equipment gives cause for serious concern [54].
	Enterprise Application Integration (EAI) is used for integrating intra and inter-organizational systems. It combines traditional integration technologies (e.g. database-oriented middleware, interface-based technologies, distributed object techniques) with new application integration technologies such as adapters and message brokers [28, 49]. Major advantages of EAI emerge through efficiently incorporate medical and administrative applications into a flexible and manageable infrastructure.

3 Research Design

The prerequisites for understanding the adoption and diffusion of the mentioned information systems in pharmacies is the study of the activities and organizational structures of the entities responsible for the procurement in hospitals [40]. Diffusion research thereby helps to explore the conditions, which increase or decrease the likelihood that a technological idea, product or practice will be adopted (an excellent overview of the history and actual ideas of diffusion research is given at [11], [16]). In his seminal work, the Diffusion of Innovations (DoI), Rogers [42] explained the mechanisms and the patterns of adoption in order to assist in predicting whether and how an innovation will be successful.

On the one hand, innovation is defined as “an idea, practice, or object that is perceived to be new by an individual or other unit of adoption” [42]. They can be categorized as product innovations, i.e. the involvement of a new or improved object whose characteristics differ significantly from previous ones, or as process innovations, i.e. the involvement of a new or significantly improved practice to enhance production and/or delivery of objects [38]. In both cases the difference in the characteristics to the prior solutions may emerge due to the application of new technologies, knowledge or materials. According to Utterback and Abernathy [52] the progress of a particular

This paper is available online at
www.jtaer.com
DOI: 10.4067/S0718-18762009000100004

innovation follows a s-curve (cf. left side of figure 2). As time goes by, the maturity of an innovation (mainly originating from many minor product or process improvements) passes through different stages. Thus innovations can be categorized as

- *emergent* (e.g. pioneering products and practices),
- *pacing* (e.g. fast-adopting products and practices),
- *disruptive* (e.g. commonly accepted products and practices),
- *mature* (e.g. established products and practices).

On the other hand, *diffusion* is understood as the “process by which an innovation is communicated through certain channels over a period of time among the members of a social system” [42]. The stages through which an innovation passes are: (1) *knowledge* (e.g. social systems and personal variables), (2) *persuasion* (e.g. in-depth understanding of characteristics of the innovation and forming of a positive attitude to it), (3) *decision* (e.g. adoption or rejection of the innovation), and finally (4) *confirmation* (e.g. consolidation of the made decision). Depending on the readiness and willingness to adopt innovations (cf. right side of figure 2), individuals or organizations can be categorized as

- *innovators* (e.g. venturesome, enterprising),
- *early adopters* (e.g. social leaders, respectable),
- *early majority* (e.g. deliberate, considered),
- *late majority* (e.g. skeptical), or
- *laggards* (traditional).

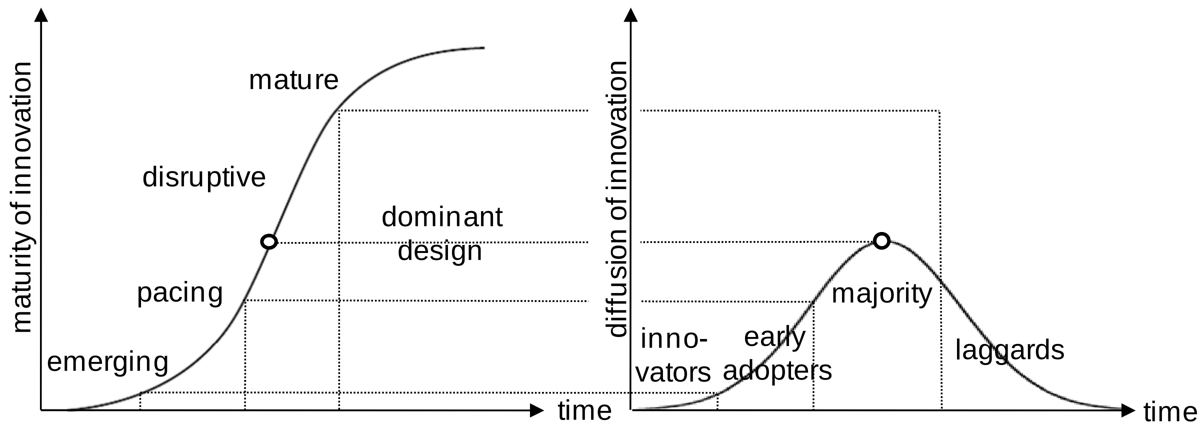


Figure 2: Relation between the Maturity and Diffusion of Innovations

As little is known about the diffusion of technological innovations in hospital pharmacies, the analysis of the activities and organizational structures is central to the research effort presented here as they represent a good means for understanding the technical and social system as well. This means that the research methods are less inclined towards experimental approaches and more inclined towards contextual observational approaches. Therefore the context is argued to be the primary source of research. For the analysis of the contextual observations an interpretive research approach is used.

Interpretive research methods follow the position that knowledge of reality is a social construction by human actors [39, 56]. “In this view, value-free data cannot be obtained, since the enquirer uses his or her preconceptions in order to guide the process of enquiry, and furthermore the researcher interacts with the human subjects of the enquiry, changing the perceptions of both parties“ [55]. Thus, interpretive research contrasts in terms of ontology, epistemology and methodology with positivist research, where it is assumed that the objective data collected by the researcher can be used to test prior hypotheses or theories [9]. It is therefore not the aim of this paper to develop hypotheses in order to test existing theories on diffusion of innovations, neither to extend these theories but to provide a grounded basis from which to continue empirical and practical investigations of the implications of e-procurement adoption in health care organizations.

Journal of Theoretical and Applied Electronic Commerce Research
ISSN 0718–1876 Electronic Version
VOL 4 / ISSUE 1 / APRIL 2009 / 23-38

This paper is available online at
www.jtaer.com
DOI: 10.4067/S0718-18762009000100004

In doing so, the case study method, as stated by Stake [45] and Yin [59], is used to conduct and present the findings of the research as this method is particularly appropriate for the study of information systems development, implementation and use within organizations [4], [37], [44] (good examples of interpretive case study research is Myer's [36] investigation on information systems implementation in three New Zealand organizations and Davis et al. [14] study on information systems failure). We define case study as "an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident" [59]. Case study research can be used to achieve various aims: to provide descriptions of phenomena, develop theory, and test theory [13] Furthermore, it can be distinguished between exploratory, descriptive, or explanatory case study designs [58]. As already mentioned above, it is not the aim of this paper to contribute to theory building or testing but to extend practical knowledge on the e-procurement usage in hospitals since little is known about this in science and practice yet. Thus, the paper presented here is rather exploratory in nature than descriptive or explanatory.

Regardless of the philosophical perspective or choice of methods, the researcher must describe how the results were arrived at, in order to establish credibility and validity [55]. In this study, expert interviews represent the essential sources of information, and are the primary means for data collection. Additionally, personal observational field notes and secondary material (e.g. process descriptions, organizational charts of the surveyed hospitals) are used to comprise the phenomenon. It is important to note that we did not involve explicit control or manipulation of any variables of the subject under study. However, to gain that deeper understanding we acknowledge our own subjectivity as part of research.

A great part of the knowledge derived from the cases is documented in the form of models (esp. process models using the Business Process Modeling Notation). We think that these models are helpful to understand the perceived realty – the object system – of the surveyed organizations (figure 3). As the interviewees perceive the health care system differently in accordance with their individual roles and objectives, an explicit form of representation is needed in order to be able to understand, explain and communicate this perceived reality. The object system thereby reflects the perceived reality of one particular person or group and also contains explicit or implicit ideas of how that perceived reality should change [25].

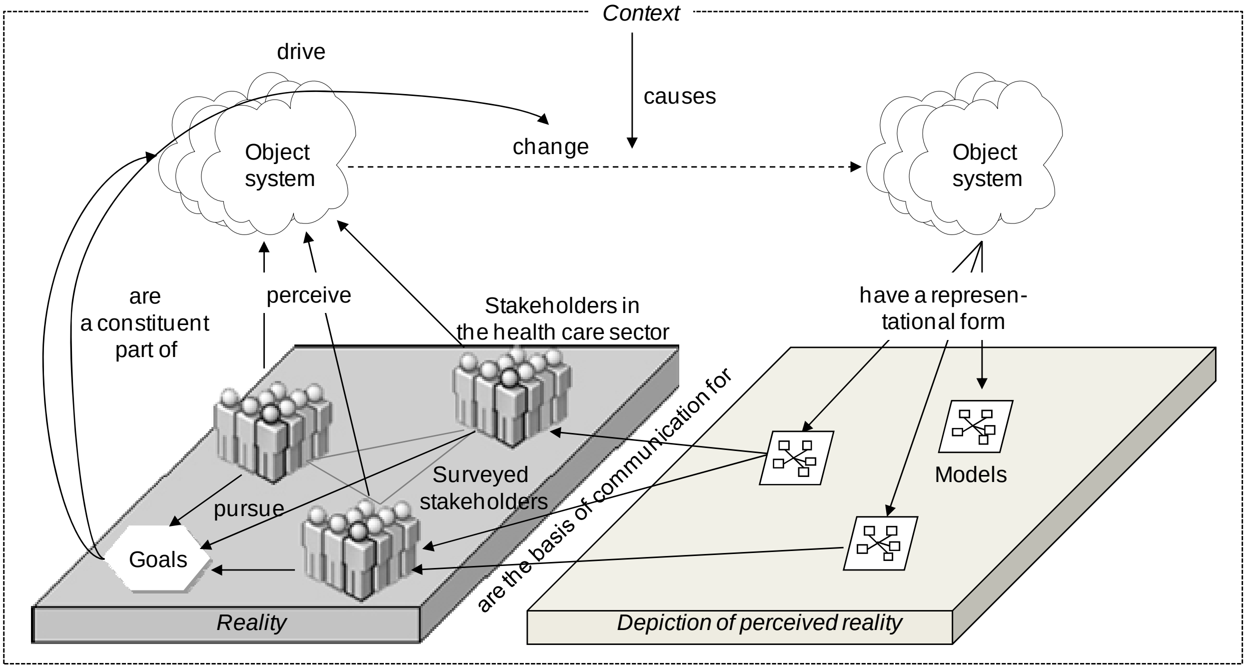


Figure 3: Models as Means for the Representation of Knowledge

4 Empirical Cases

To try to gain the necessary information on the state of adoption of ICT used in hospital pharmacies the convenience sampling method was used to identify appropriate cases. The multi-case study consists of three single cases with differing organizational structure and automation degrees (table 2):

Journal of Theoretical and Applied Electronic Commerce Research
ISSN 0718–1876 Electronic Version
VOL 4 / ISSUE 1 / APRIL 2009 / 23-38

This paper is available online at
www.jtaer.com
DOI: 10.4067/S0718-18762009000100004

Table 2: Characteristics of the Analyzed Hospitals

Characteristics	**Unit of Analysis**		
	Hospital A	Hospital B	Hospital C
# Beds	400	350	300
# Inpatients/year	9,500	8,000	7,000
# Outpatients/year	46,000	40,000	24,000
# Drugs in assortment	1,200	1,200	8,000
# Stocked drugs	800	800	1,000
Automation level	low	low	moderate
Automation focus	department	enterprise	supply chain
DoI characterization	laggard or late majority	late majority or early majority	early adopter or innovator

The first unit of analysis is a pharmacy of a regional hospital with about 400 beds and a total of 55,500 patients a year. The hospital's pharmacy manages an assortment of almost 1,200 different drugs, thereof 800 are in stock. The automation level of the hospital pharmacy is rather low compared with other industries and is mainly focused on the improvement of administrative and personnel issues of the specific organizational unit itself, thus leaving behind potential benefits of intra-organizational and inter-organizational collaboration. In terms of the adopter categories defined in section 2, it can be characterized as laggard or late majority.

The second unit of analysis is a pharmacy of a regional hospital with 48,000 patients annually and 350 beds. The pharmacy under study manages an assortment of 1,200 different drugs. In respect of the automation level of the pharmacy it is comparable with the first hospital but the automation is more focused on optimizing not only the own organizational unit but also the internal interfaces (e.g. to the logistics department). Overall, it can be characterized as late majority or early majority adopter.

The third unit of analysis is a pharmacy of a smaller rural hospital with 300 beds and about 31,000 patients a year. The pharmacy under study is responsible for the procurement of drugs and of medical devices as well. Thus slightly more items (a total of 8,000) are in the line of goods and 1,000 in stock. In comparison with the two other hospitals this pharmacy has a higher automation level (e.g. use of e-marketplace for ordering) and is rather focused on optimizing the supply chain (from supplier to the patient). In terms of the adopter categories, it can be characterized as early adopter or innovator.

4.1 Scope of the Multi-Case Study

The selected cases have an inside and an outside. “Certain components lie within the system, within the boundaries of the case; certain features lie outside” [45]. As there is a wide range of differing definitions of the term ‘procurement’ as well as of ‘e-procurement’ a clarification of the scope of the multi-case study is needed. Therefore, as a framework for the analysis, the Supply Chain Operations Reference-model (SCOR) is used [47]. The framework differentiates three levels of analysis – top level, configuration level and process element level (figure 4).

At the top level, five distinct business processes are distinguished: plan, source, make, deliver and return. Business processes can be defined as sets of partially ordered and coordinated tasks and thereof deduced ‘atomic’ activities, often cutting across functional boundaries within organizations [12, 30]. As this contribution is aiming at investigating the status of adoption of e-procurement in hospital pharmacies, the emphasis has to be placed on the sourcing processes. Other basic SCOR processes such as plan, make and deliver are not reflected in detail.

At the configuration level, the main tasks of the processes are defined. In order to investigate both stable and dynamic supplier relationships, the ordering routines of both regular products which are in a hospital's line of goods (source stocked products) and ad-hoc requests (source make-to-order) will be part of the study. The focus will lie on the procurement of drugs since the complexity of provisioning is superior compared with other material groups like for example medical products or consumables.

At the process element level, the respective activities are analyzed in more detail. This allows the detection of organizational weaknesses and the identification of areas of improvement where ICT can enhance an activity or even the entire process. Thus, the cases will first and foremost concentrate on this level of detail for analysis.

Journal of Theoretical and Applied Electronic Commerce Research
ISSN 0718–1876 Electronic Version
VOL 4 / ISSUE 1 / APRIL 2009 / 23-38

This paper is available online at
www.jtaer.com
DOI: 10.4067/S0718-18762009000100004

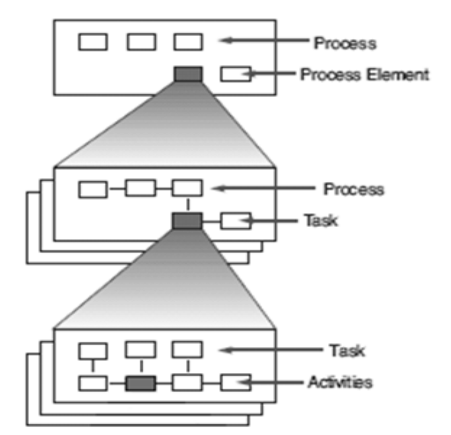
	Level	Schematic	Case Study Focus
Supply Chain Operations Reference-model	Top Level (Process Types)		Processes: sourcing processes of hospital pharmacies
	Configuration Level (Process Categories)		Tasks: order routine for regular drugs and ad-hoc requests for special drugs
	Process Element Level (Decompose Processes)		Activities: overview of all work practices and used ICT functionalities

Figure 4: SCOR as Analytical Framework for the Multi-Case Study

4.2 Analysis of Regular Ordering Routine

Public hospitals have a permanent obligation for service delivery, not only under the usual circumstances, but also in case of a crisis [31]. Therefore only a marginal fault tolerance in the procurement processes is admissible [32]. Sophisticated mechanisms to manage the entire supply chain are needed. However, in health care this is more aspiration than reality [8]. To understand the current drawbacks it is crucial to have an overview of the present situation. A key task is the general order routine for purchasing regular drugs (corresponds to source stocked products in the SCOR model). We define ‘regular orders’ as booking appointments for drugs which are in the line of goods of the hospitals (e.g. specified in a drug list). The order routine consists of ten basic activities (figure 5):

1. When a demand for a drug occurs, the nursing staff checks the ward repository for the requested goods.
2. If it is in stock, the medicine can be prepared for the patient’s treatment.
3. If not, an internal order is sent to the pharmacy.
4. In a next step, the internal order is received and checked by the pharmacist.
5. Then the hospital’s pharmacy repository is searched for the requested drug.
6. If it is in stock, the medicine is prepared for internal delivery and transported to the demanding ward.
7. If not, the pharmacist searches within his supplier base for an appropriate provider.
8. Then a purchasing order to the established supplier for the required drug is placed (black box: the activities of the supplier remain unconsidered since they are outside of the case).
9. After a certain time the hospital pharmacist receives the requested drugs from the supplier.
10. By day, the drugs arrive to the ward and are then prepared for the patient’s treatment.

Journal of Theoretical and Applied Electronic Commerce Research
ISSN 0718–1876 Electronic Version
VOL 4 / ISSUE 1 / APRIL 2009 / 23-38

This paper is available online at
www.jtaer.com
DOI: 10.4067/S0718-18762009000100004

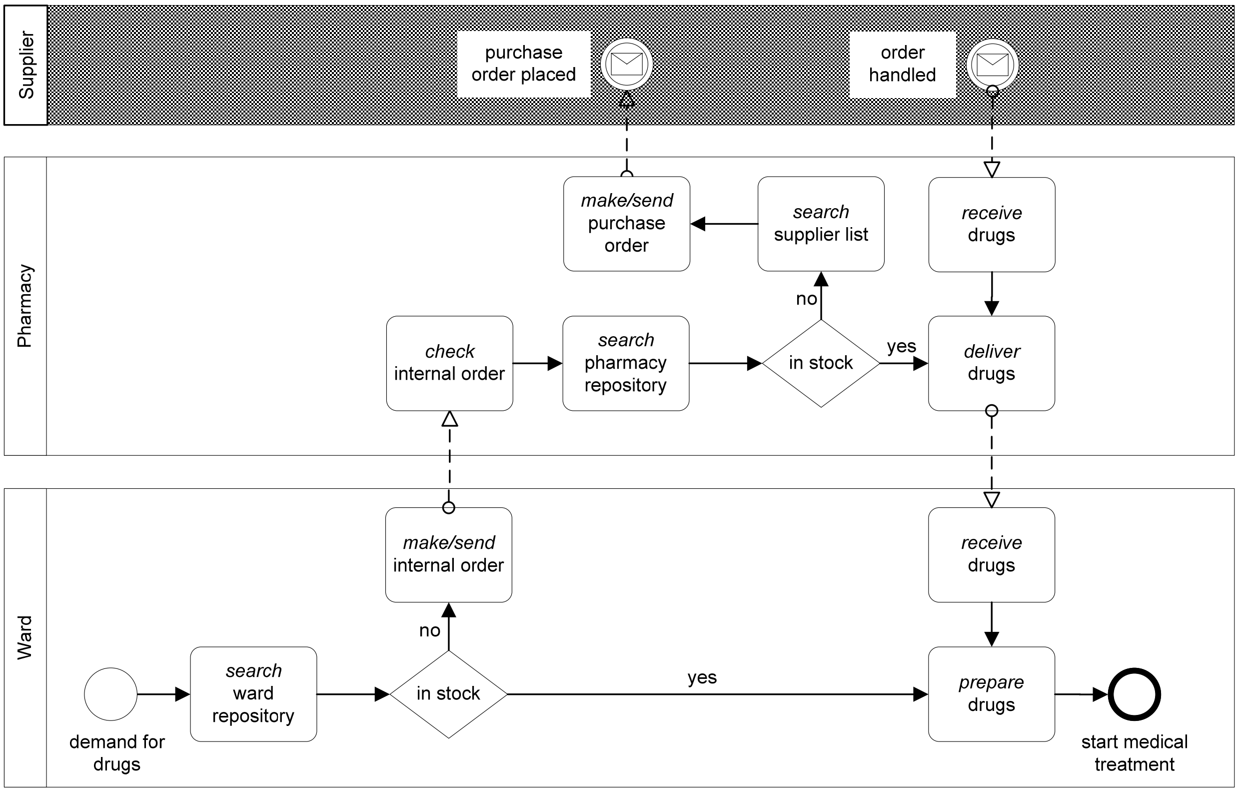


Figure 5: Regular Ordering Routine for Drugs within the Assortment of Goods

Although the flow of activities for regular ordering routines is for all the surveyed hospitals more or less identical, considerable differences in the realization exist (table 3).

In Hospital A the use of ICT is focused on the needs of the pharmacy staff. For this reason the activities on the part of the nursing staff have only rudimentary ICT support. As the wards repository is not standardized and not managed electronically in a PIS, there is no inventory control (i.e. the received drugs are not managed in the pharmacy or materials management IS). Feedback loops that indicate if patients effectively received the right drugs are missing as no automated dispensing systems are implemented. Hence, there is no feedback loop that indicates if the patients effectively received the right drugs. In general, ICT is only used for in-house ordering and for managing the pharmacy inventory. Additionally, due to the manual data entry of in-house orders and of master data (e.g. product and supplier information), poor data quality exists. As a further consequence of the localized use of ICT, important internal (e.g. to the logistics department) and external (e.g. to the suppliers) interfaces are lacking as well. The resulting media breaks give rise to more problems such as missing information of order and delivery status, additional labor effort for manual ordering and lengthy process cycle times.

Although Hospital B has a comparable automation level, the focus of ICT use lies more in the cross-functional optimization of processes. As a result, the ward repositories are highly standardized (i.e. every repository has a defined assortment of drugs which are labeled by bar code tags) and thus can be centrally managed in the PIS. Inventory control is possible since all in-house orders have to be placed electronically by scanning the corresponding bar code. However, the administration of drugs is still out of control, thus leaving behind the potential of reducing medical errors during the dispensing of drugs. Looking inside the pharmacy, problems similar to those seen in Hospital A exist here, too. Master data, purchasing orders and delivery preparation is still processed manually.

As Hospital C is rather focused on the optimization of the entire supply chain, internal and external interfaces are better developed. Internally, the realization is identical with Hospital B, hence using the bar code technology for inventory control and in-house ordering. Externally, an electronic purchasing platform which is connected with the internal PIS is used for the collaboration with the different suppliers. More than 80 per cent of the purchasing orders are handled through this platform. In addition, master data is obtained from a professional information provider. However, there are still areas for improvement left. For example the administration of drugs is out of control or the preparation of drugs is mainly done by hand yet. Since this is a time consuming and risky task, the use of ICT-enabled drugs management (e.g. unit dose dispensing system) should be considered.

Journal of Theoretical and Applied Electronic Commerce Research
ISSN 0718–1876 Electronic Version
VOL 4 / ISSUE 1 / APRIL 2009 / 23-38

This paper is available online at
www.jtaer.com
DOI: 10.4067/S0718-18762009000100004

Table 3: Realization of Order Routine for Regular Drugs (Source Stocked Products)

Activity	**Implementation**		
	Hospital A	Hospital B	Hospital C
1. Search ward repository	Manual handling, no standardized repository	PIS with standardized repository	PIS with standardized repository
2. Prepare drugs	Manual handling	Manual handling	Manual handling
3. Make/send internal order	Manual data entry, order by e-mail	Supported by bar code system, order by e-mail	Supported by bar code system, order by desktop purchasing tool
4. Check internal order	Manual handling of e-mail	Manual handling of e-mail	Automated alerts by desktop purchasing tool
5. Search pharmacy repository	Manual handling of search and master data entry	Automated search (PIS), but manual master data entry	Automated search (PIS); master data sourced from provider
6. Deliver drugs	Manual handling	Manual handling	Manual handling
7. Search supplier list	Manual search in paper-based list	Manual search in paper-based list	Automated search in supplier portal
8. Make/send purchase order	Fax and telephone	Fax and telephone	Supplier portal
9. Receive drugs (pharmacy)	Manual handling of invoice entry	Invoice entry supported by bar code system	Invoice entry supported by bar code system
10. Receive drugs (ward)	Out of control, no data entry	Controlled by bar code system	Controlled by bar code system

4.3 Analysis of Ad-hoc Requests

As people are becoming increasingly mobile (e.g. frontier runners, tourists, seasonal workers) the hospitals are facing new challenges in the assurance of the continuity of clinical care of patients. Thus, requests for drugs which are not in the hospital's line of goods are very common as public hospitals have a permanent obligation for service delivery. Hence, the order routine for ad-hoc requests is becoming increasingly important in the hospitals and therefore needs special attention (corresponds to *source make-to-order* in the SCOR model). We define 'ad hoc request' as booking appointments for drugs which are not in the line of goods of the hospitals. Again, ten basic activities can be differentiated (figure 6):

1. When a demand for a special drug occurs, the physician fills out a prescription with the general information of the needed drug. The prescription is either sent directly by the physician or by the nursing staff to the hospital pharmacy.

2. The pharmacist receives the prescription and checks it for errors.

3. If the prescription contains inconsistencies (e.g. illegibility of dose), it is returned to the requester.

4. The physician analyzes the prescription and makes the necessary changes. The prescription then is sent to the pharmacy again.

5. If the prescription is valid, the pharmacist searches for an appropriate supplier for this drug.

6. Then a purchasing order to a new or established supplier for the required drug is placed.

7. After a certain time the hospital pharmacist receives the requested drugs from the supplier.

8. In a next step, the drugs are prepared for internal delivery and transported to the wards.

9. By day, the nursing staff receives the requested drugs.

10. Then the medicine is prepared for the patient's treatment.

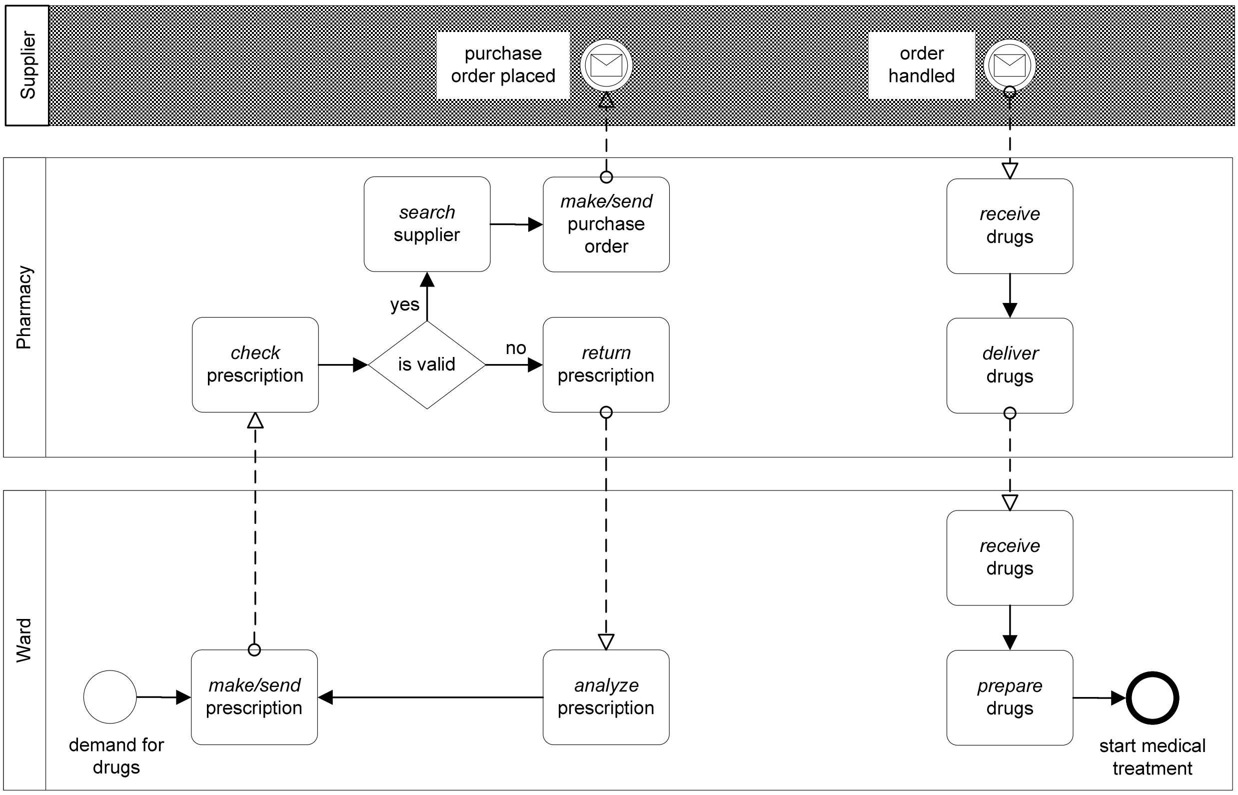


Figure 6: Ad-hoc Request for Special Drugs

The situation in Hospital A, B, and C are practically identical for activities 1-4 (table 4). All activities with reference to the handling of prescriptions are processed manually by filling out, sending, and processing paper-based forms (figure 7). This is very time consuming for physicians, nursing staff, and pharmacists and yields to lengthy process cycle times, mispurchasing and so forth. However, much more serious in this regard are medication errors, possibly caused by reason of illegible prescriptions [17]. In the United States it is assumed that medication errors provoke at least one death every day and injure approximately 1.3 million people annually [51]. Hence, there is room for major improvement in Switzerland.

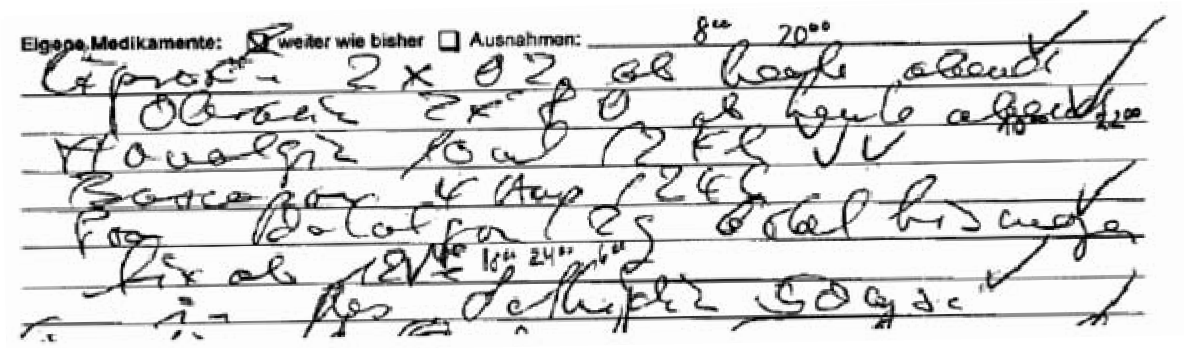


Figure 7: Example of Paper-based Prescription

For the more administrative part of the ad-hoc request routine (activities 5-8), a more varying situation was found. When searching for an appropriate supplier, Hospital A and B spend a lot of time in the Internet as only the personal network of known suppliers is recorded in the PIS. Purchasing orders are placed by fax or by telephone. The status of orders and shipments is therefore uncontrollable. When talking to the pharmacists of Hospital A and B, they admitted that this is a major problem. As the number of ad-hoc requests is rising, it is more and more difficult for them to have an accurate overview of all pending purchasing orders.

In contrast, *Hospital C* uses an electronic supplier platform for searching providers and processing orders (the same as for the regular order routine). Hence, precious labor time can be saved and used for more valuable activities (e.g. for checking the prescription and for coordinating patient treatment plans with the attending physician). However, as no activity-based costing is implemented in Hospital C, no detailed information about the real efficiency increase can be given.

Journal of Theoretical and Applied Electronic Commerce Research
ISSN 0718–1876 Electronic Version
VOL 4 / ISSUE 1 / APRIL 2009 / 23-38

This paper is available online at
www.jtaer.com
DOI: 10.4067/S0718-18762009000100004

Table 4: Realization of Order Routine for Ad-hoc Requests (Source Make-to-Order)

Activity	**Implementation**		
	Hospital A	Hospital B	Hospital C
1. Make/send prescription	Manual handling of paper-based form	Manual handling of paper-based form	Manual handling of paper-based form
2. Check prescription	Manual handling	Manual handling	Manual handling
3. Return prescription	Manual handling of paper-based form	Manual handling of paper-based form	Manual handling of paper-based form
4. Analyze prescription	Manual handling	Manual handling	Manual handling
5. Search supplier	Web search	Web search	Automated search in supplier portal
6. Make/send purchase order	Fax and telephone	Fax and telephone	Supplier portal
7. Receive drugs (pharmacy)	Manual handling of invoice entry	Invoice entry supported by bar code system	Invoice entry supported by bar code system
8. Deliver drugs	Manual handling	Manual handling	Manual handling
9. Receive drugs (ward)	Out of control, no data entry	Controlled by bar code system	Controlled by bar code system
10. Prepare drugs	Manual handling	Manual handling	Manual handling

5 Suggestions for a Forward-Looking Use of ICT in Pharmacies

The presented case studies showed that hospital pharmacies in Switzerland are still confronted with

- paper shuffling (e.g. manual requisitions and purchasing orders, paper-based pricing information),
- multiple product handling activities (e.g. two sub-processes for regular and special drugs),
- excessive inventory carrying costs (e.g. manual entry and update of product information),
- lengthy product ordering and delivery cycle times (e.g. several process iterations when prescription is incomplete),
- data quality issues (e.g. little information on product location and product utilization),
- process quality issues (e.g. insufficient inventory control or no existing feedback loops that indicate if patients effectively received the right drugs), and
- poorly developed interfaces to suppliers (i.e. supplier is an unpredictable black box).

Therefore it is our opinion that major organizational changes are needed in the future. First of all, we think that sustainable benefits will emerge through the implementation of the following technologies:

- RFID-technology or bar coding systems for the tagging of drugs in order to make drugs traceable and to optimize inventory control and ultimately reduce storage costs [46],
- CPOE in order to replace illegible paper-based prescriptions, thus accelerating cycle times and improving patient safety [18], [27], [43],
- ADS and UDDS to reduce the preparation time of the nursing staff and pharmaceutical assistants as well as to make drugs dispensing more secure for the patients [35],
- SRM (e.g. e-auctions, e-marketplaces, supplier self services) amongst others for the collaboration with and the control of suppliers in order to enhance data quality (e.g. accuracy, timeliness, correctness of product and supplier master data) and process quality (e.g. transparency of ordering status throughout the process) [32], and finally
- EAI in order to integrate the various sources where patient, product, and supplier master data is stored and administered (e.g. CIS, PIS, materials management systems, desktop purchasing tool) [28].

In order to efficiently implement the suggested technologies, processes have to be re-designed insofar that

- procurement activities are consolidated (e.g. a common approach for ordering of drugs and other materials),

- interfaces are optimized (e.g. integrating product and supplier master data in the PIS in order to enhance transparency, digitize the handling of prescriptions so that consistency checks and other activities can be automated),

- laborious or precarious tasks are reduced (e.g. check prescription, search for supplier) or at least complemented by consistency checks (e.g. contraindication alert, out of stock warning, empty drip-feeding),

- effectiveness of the activities is enhanced (e.g. periodical analysis of the drugs market and monitoring of the supplier's performance).

A proposition of a possible scenario for the future ICT use in hospital pharmacies is illustrated in figure 8. It shows that in order to tap the full potential of e-procurement, an interaction of the different applications is needed, making the presented 'enabling technologies' such as bar coding systems and EAI important pieces of the overall architecture. Nevertheless, significant benefits can also be achieved by gradually implementing a respective system (e.g. CPOE for reducing medication errors, SRM for enhancing the efficiency of administrative procurement activities). However, from the point of view of sustainable cost-savings, it is arguable why a hospital has to manage all the analyzed tasks on its own (e.g. inventory control). In future, most benefits in drugs supply management will certainly emerge through the centralization of procurement and logistics by intensification of the collaboration between the hospitals (e.g. buying syndicates) and through outsourcing of certain activities to the supplier (e.g. vendor managed inventories, cross docking) [32]. However, this will cause new problems and will need advanced knowledge of both, managerial and technical nature.

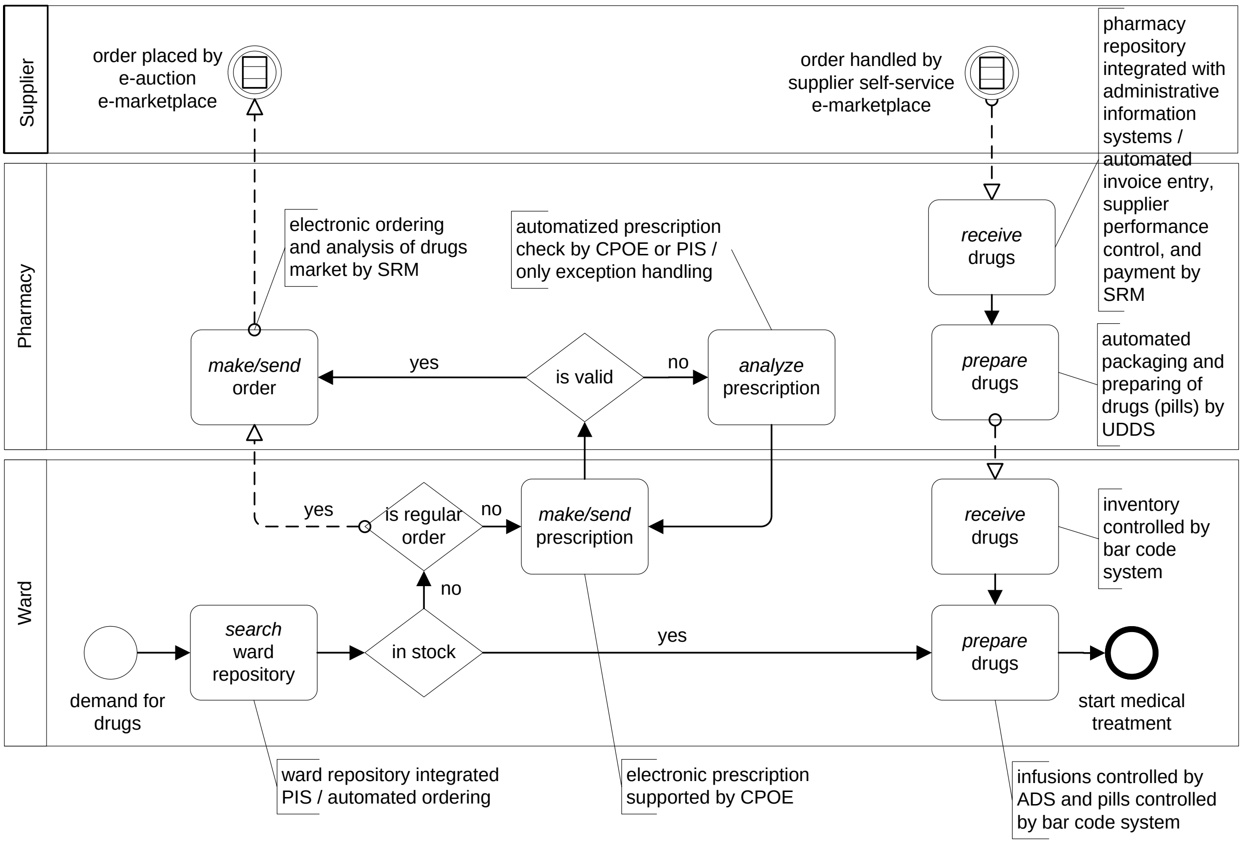


Figure 8: Future Scenario for Drugs Supply in Hospitals

6 Conclusion

The use of ICT is actually seen as opportunity to improve not only the requested organizational performance but also quality of health services by reducing redundancy and duplication of activities and thus leading to fundamental cost-savings [57] and enhanced patient safety [1]. To understand the current drawbacks it is crucial to gain a general view on where the hospitals stand today so that areas of improvement for further ICT use can be found. On the basis of interpretive case study research, we therefore explored the current adoption of e-procurement technologies in hospital pharmacies. In doing so, we focused on the process for ordering regular drugs and on the ad-hoc requests, given that the number of special drugs is continuously increasing. By means of modeling these differing processes we identified the present weaknesses but also many opportunities for practitioners to leverage administrative as well as medical duties.

However, from a research perspective it can be said, that the maturity of the surveyed information systems is in most instances far from being ripe (figure 9). Many advantageous applications such as CPOE or UDDS are still in the knowledge or persuasion phase of diffusion. Therefore future research should be directed to applying existing theories and proposing new theories in order to enhance the acceptance of these beneficial technologies. Furthermore, new artifacts (e.g. methods, models and instantiations) [24] are needed to effectively build the linkage between medical and administrative applications. Only in this way it will be possible to holistically enhance quality and cost of hospital pharmacies.

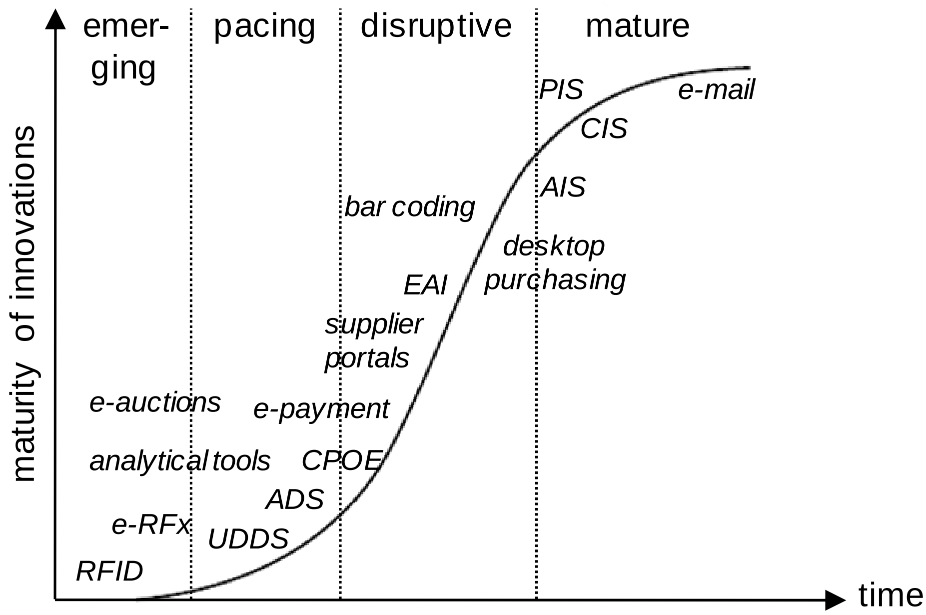


Figure 9: Maturity of Innovations in the Surveyed Hospitals

References

[1] M. Adams, D. Bates, G. Coffman et al., Saving Lives, Saving Money: The Imperative for Computerized Physician Order Entry in Massachusetts Hospital, Massachusetts Technology Collaborative and New England Healthcare Institute, Boston, 2008.
[2] Arthur Anderson, The Value of eCommerce in the Healthcare Supply Chain, Arthur Anderson, Chicago, 2001.
[3] D. W. Bates, L. L. Leape, D. J. Cullen et al., Effect of Computerized Physician Order Entry and a Team Intervention on Prevention of Serious Medication Errors, Journal of the American Medical Association, vol. 280, no. 15, pp. 1311-1316, 1998.
[4] I. Benbasat, D. K. Goldstein, and M. Mead, The Case Research Strategy in Studies of Information Systems, MIS Quarterly, vol. 11, no. 3, pp. 369-386, 1987.
[5] M. C. Beuscart-Zephir, S. Pelayo, P. Degoulet et al., A Usability Study of CPOE's Medication Administration Functions: Impact on Physician-Nurse Cooperation, Sudies in Health Technologies and Informatics, vol. 107, no. 2, pp. 1018-1022, 2004.
[6] Biohealthmatics.com. (2006, August). Pharmacy Information Systems, [Online]. Available: http://www.biohealthmatics.com/technologies/his/pis.aspx.
[7] E. Brynjolfsson, and S. Yang, Information Technology and Productivity: A Review of the Literature, Advances in Computers, vol. 43, pp. 179-214, 1996.
[8] L. R. Burns, The Health Care Value Chain: Producers, Purchasers, and Providers, San Francisco: Jossey-Bass, 2002.
[9] W. Chen, and R. Hirschheim, A Paradigmatic and Methodological Examination of Information Systems Research from 1991 to 2001, Information Systems Journal, vol. 14, no. 3, pp. 197-235, 2004.
[10] K. Chung, Y. B. Choi, and S. Moon, Toward Ef?cient Medication Error Reduction: Error-Reducing Information Management Systems, Journal of Medical Systems, vol. 27, no. 6, pp. 553-560, 2003.

[11] R. Clarke. (2001, September). Innovation Diffusion Resources, [Online]. Available: http://www.anu.edu.au/people/Roger.Clarke/SOS/InnDiffISW.html.
[12] B. Curtis, M. I. Kellner, and J. Over, Process Modeling, Communications of the ACM, vol. 35, no. 9, pp. 75-90, 1992.
[13] P. Darke, G. Shanks, and M. Broadbent, Successfully Completing Case Study Research: Combining Rigour, Relevance and Pragmatism, Information Systems Journal, vol. 8, no. 4, pp. 273-289, 1998.
[14] G. B. Davis, A. S. Lee, K. R. Nickles et al., Diagnosis of an Information System Failure: A Framework and Interpretive Process, Information and Management, vol. 23, no. 5, pp. 293-318, 1992.
[15] P. Enrado. (2005, January). Buyers guide: Pharmacy Systems, [Online]. Available: http://www.healthcareitnews.com/story.cms?id=3786.
[16] B. Furneaux. (2008, January). Diffusion of Innovations Theory, [Online]. Available: http://www.fsc.yorku.ca/york/istheory/wiki/index.php/Diffusion_of_innovations_theory.
[17] M. F. Furukawa, T. S. Raghu, T. J. Spaulding et al., Adoption of Health Information Technology for Medication Safety in U.S. Hospitals, Health Affairs, vol. 27, no. 3, pp. 865-875, 2008.
[18] W. L. Galanter, R. J. Didomenico, and A. Polikaitis, A Trial of Automated Decision Support Alerts for Contraindicated Medications Using Computerized Physician Order Entry, Journal of the American Medical Informatics Association, vol. 12, pp. 269-274, 2005.
[19] A. Gericke, P. Rohner, and R. Winter, Networkability in the Health Care Sector - Necessity, Measurement and Systematic Development as the Prerequisites for Increasing the Operational Efficiency of Administrative Processes, in Proceedings of 17th Australasian Conference on Information Systems. Adelaide, Australia. Australasian Association for Information Systems, 2006, CD-Rom.
[20] German Association for Medical Technology. (2007, February). Elektronisches Beschaffungswesen im Gesundheitsmarkt vor dem Durchbruch, [Online]. Available: http://www.bvmed.de/themen/E-Commerce/pressemitteilung/BVMed-Umfrage_Elektronisches_Beschaffungswesen_im_Gesundheitsmarkt_vor_dem_Durchbruch.html.
[21] R. J. Grossman, The Battle to Control Online Purchasing, Health Forum Journal, vol. 43, no. 1, pp. 18-21, 2000.
[22] P. Harrop, and T. Crotch-Harvey, RFID for Healthcare and Pharmaceuticals 2008-2018, IDTechEx, Cambridge, USA, 2008.
[23] J. Herrmann, and B. Hodgson, SRM: Leveraging the Supply Base for Competitive Advantage, in Proceedings of SMTA International Conference. Chicago, USA, 2001, pp. 1-5.
[24] A. R. Hevner, S. T. March, J. Park et al., Design Science in Information System Research, MIS Quarterly, vol. 28, no. 1, pp. 75-101, 2004.
[25] R. Hirschheim, H. K. Klein, and K. Lyytinen, Information Systems Development and Data Modeling: Conceptual and Philosophical Foundations, Cambridge: Cambridge University Press, 1995.
[26] Joint Commission International Center for Patient Safety, Technology in Patient Safety: Using Identification Bands to Reduce Patient Identification Errors, Joint Commission Perspectives on Patient Safety, vol. 5, pp. 1-10, 2005.
[27] Joint Commission International Center for Patient Safety. (2007, May). Look-Alike, Sound-Alike Medication Names, [Online]. Available: http://www.jcipatientsafety.org/fpdf/Presskit/PS-Solution1.pdf.
[28] K. Khoumbati, and M. Themistocleous, Integrating the IT Infrastructures in Healthcare Organisations: A Proposition of Influential Factors, Electronic Journal of e-Government, vol. 4, no. 1, pp. 27-36, 2006.
[29] R. Koppel, J. P. Metlay, A. Cohen et al., Role of Computerized Physician Order Entry Systems in Facilitating Medication Errors, Journal of the American Medical Association, vol. 293, no. 10, pp. 1197-1203, 2005.
[30] F. Leymann, and W. Altenhuber, Managing Business Processes as an Information Resource, IBM Systems Journal, vol. 33, no. 2, pp. 326-348, 1994.
[31] G. A. Mc Guire, Development of a Supply Chain Management Framework for Health Care Goods Provided as Humanitarian Assistance in Complex Political Emergencies, Vienna University of Economics and Business Administration, Vienna, 2006.
[32] T. Mettler, and P. Rohner, Supplier Relationship Management in Health Care Practice – A Case Study, in Proceedings of 6th CollECTeR Iberoamérica. Madrid, Spain, 2008, CD-Rom.
[33] T. Mettler, P. Rohner, and R. Winter, Factors Influencing Networkability in the Health Care Sector - Derivation and Empirical Validation, in Proceedings of 12th International Symposium for Health Information Management Research. Sheffield, United Kingdom. University of Sheffield, 2007, pp. 51-62.
[34] T. Mettler, and V. Vimarlund, Understanding Business Intelligence in the Context of Health Care, in Proceedings of the 13th International Symposium for Health Information Management Research. Auckland, New Zealand. Massey University, 2008, pp. 61-69.
[35] M. D. Murray, and K. G. Shojania. (2001, July). Unit-Dose Drug Distribution Systems, Agency for Healthcare Research and Quality. [Online].
[36] M. D. Myers, Dialectical Hermeneutics: A Theoretical Framework for the Implementation of Information Systems, Information Systems Journal, vol. 5, no. 1, pp. 51-70, 1995.
[37] M. D. Myers, Qualitative Research in Information Systems, MIS Quarterly, vol. 21, no. 1, pp. 241-242, 1997.
[38] OECD, The Oslo Manual: Proposed Guidelines for Collecting and Interpreting technological Innovation Data, Paris: OECD, 1997.
[39] W. J. Orlikowski, and J. J. Baroudi, Studying Information Technology in Organisations: Research Approaches and Assumptions, Information Systems Research, vol. 2, no. 1, pp. 1-28, 1991.
[40] N. A. Panayiotou, S. P. Gayialis, and I. P. Tatsiopoulos, An E-Procurement System for Governmental Purchasing, International Journal of Production Economics, vol. 90, no. 1, pp. 79-102, 2004.

[41] M. E. Porter, and E. Olmsted Teisberg, Redefining Competition in Health Care, Harvard Business Review, vol. 82, no. 6, pp. 64-76, 2004.
[42] E. M. Rogers, Diffusion of Innovations, 5 ed., New York: Free Press, 2003.
[43] T. A. Shamliyan, S. Duval, J. Du et al., Just what the Doctor Ordered. Review of the Evidence of the Impact of a Computerized Physician Order System on Medication Errors, Health Services Research, vol. 43, no. 1, pp. 32-53, 2008.
[44] N. Smith, The Case Study: A Useful Research Method for Information Management, Journal of Information Technology, vol. 5, no. 3, pp. 123-133, 1990.
[45] R. E. Stake, Multiple Case Study Analysis, New York: The Guilford Press, 2006.
[46] M. S. Strassner, T, Today's Impact of Ubiquitous Computing on Business Process, in Proceedings of First International Conference on Pervasive Computing, Zürich, Switzerland, 2002, pp. 62-74.
[47] Supply Chain Council. (2008, April). Supply-Chain Operations Reference-Model, [Online]. Available: http://www.supply-chain.org.
[48] Swisslog. (2008, November). Pharmacy Automation System, [Online]. Available: http://www.swisslog.com/index/hcs-index/hcs-pharmacy/hcs-pharmacycomponents.htm.
[49] M. Themistocleous, and Z. Irani, A Model for Adopting Enterprise Application Integration Technology, in Proceedings of Working Conference on the Adoption and Diffusion of IT in an Environment of Critical Change Sydney, Australia, 2002, pp. 61-76.
[50] U.S. Food and Drug Administration. (2004, February). FDA Issues Bar Code Regulation, [Online]. Available: http://www.fda.gov/oc/initiatives/barcode-sadr/fs-barcode.html.
[51] U.S. Food and Drug Administration. (2008, November). Medication errors, [Online]. Available: http://www.fda.gov/cder/handbook/mederror.htm.
[52] J. M. Utterback, and W. J. Abernathy, A Dynamic Model of Process and Product Innovation, Omega, vol. 3, no. 6, pp. 639-656, 1975.
[53] J. H. van Bemmel, and M. A. Musen. (1999, March). Handbook of Medical Informatics, [Online]. Available: http://www.mieur.nl/mihandbook/r_3_3/handbook/home.htm.
[54] R. van der Togt, E. J. van Lieshout, R. Hensbroek et al., Electromagnetic Interference From Radio Frequency Identification Inducing Potentially Hazardous Incidents in Critical Care Medical Equipment, Journal of the American Medical Association, vol. 299, no. 24, pp. 2884-2890, 2008.
[55] G. Walsham, The Emergence of Interpretivism in IS Research, Information Systems Research, vol. 6, no. 4, pp. 376-394, 1995.
[56] R. Weber, Editor's Comment - The Rhetoric of Positivism Versus Interpretivism: A Personal View, MIS Quarterly, vol. 28, no. 1, pp. iii-xii, 2004.
[57] World Health Organization. (2005, April). eHealth: Report by the Secretariat, [Online]. Available: http://www.who.int/gb/ebwha/pdf_files/WHA58/A58_21-en.pdf.
[58] R. K. Yin, The Case Study as a Serious Research Strategy, Science Communication, vol. 3, no. 1, pp. 97-114, 1981.
[59] R. K. Yin, Case Study Research: Design and Methods, 3 ed., Thousand Oaks: Sage Publications, 2003.