Supporting Collaborative Work through ICT

How End-users Think of and Adopt Integrated Health Information Systems

Bahlol Rahimi
Tanrının Adı ve Yadile

To

Setareh

キラーシ

And

My Parents
Abstract

Health Information Systems (HISs) are implemented to support individuals, organizations, and society, making work processes integrated and contributing to increase service quality and patient safety. However, the outcomes of many HIS implementations in both primary care and hospital settings have either not met yet all the expectations decision-makers identified or have failed in their implementation. There is, therefore, a growing interest in increasing knowledge about prerequisites to be fulfilled in order to make the implementation and adoption of HIS more effective and to improve collaboration between healthcare providers.

The general purpose of the work presented in this thesis is to explore issues related to the implementation, use, and adoption of HISs and its contribution for improving inter- and intra-organizational collaboration in a healthcare context. The studies included have, however, different research objectives and consequently used different research methods such as case study, literature review, meta-analysis, and surveys. The selection of the research methodology has thus depended on the aim of the studies and their expected results.

In the first study performed we showed that there is no standard framework to evaluate effects and outputs of implementation and use of ICT-based applications in the healthcare setting, which makes the comparison of international results not possible yet.

Critical issues, such as techniques employed to teach the staff when using integrated system, involvement of the users in the implementation process, and the efficiency of the human computer interface were particularly reported in the second study included in this thesis. The results of this study also indicated that the development of evidence-based implementation
processes should be considered in order to diminish unexpected outputs that affect users, patients and stakeholders.

We learned in the third study, that merely implementing of a HIS will not automatically increase organizational efficiency. Strategic, tactical, and operational actions have to be taken into consideration, including management involvement, integration in healthcare workflow, establishing compatibility between software and hardware, user involvement, and education and training.

When using an Integrated Electronic Prescribing System (IEPS), pharmacies staff declared expedited the processing of prescriptions, increased patient safety, and reduced the risk for prescription errors, as well as the handing over of erroneous medications to patients. However, they stated also that the system does not avoid all mistakes or errors and medication errors still occur. We documented, however, in general, positive opinions about the IEPS system in the fifth article. The results in this article indicated that safety of the system compared to a paper-based one has increased. The results showed also an impact on customer relations with the pharmacy; and prevention of errors. However, besides finding an adoption of the IEPS, we identified a series of undesired and non planned outputs that affect the efficiency and efficacy of use of the system.

Finally, we captured in the sixth study indications for non-optimality in the computer provider entry system. This is because; the system was not adapted to the three-quarters of physicians and one-half of nurses’ specific professional practice. Respondents pointed out also human-computer interaction constrains when using the system. They indicated also the fact that the system could lead to adverse drug events in some circumstances.

The work presented in this thesis contributes to increase knowledge in the area of health informatics on how ICT supports inter- and intra-organizational collaborative work in a healthcare context and to identify factors and prerequisites needed to be taken into consideration when implementing new generations of HIS.
List of Publications

This thesis is based on six papers, which will be referred to in the next by their roman numerals.


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Introduction

1 Motivation

The science and practice of health informatics changed radically in the late 1970s and early 1980s when computer use began to become increasingly common in healthcare environments [1]. Since then, improvements in the speed and processing power of computers, computer networks, and the Internet has led to increased accessibility and availability of information for healthcare professionals to support their decision-making processes [2-5].

It is now hard to imagine healthcare without Information and Communication Technology (ICT) based applications for both the accumulation and interchange of clinical information [6]. For example, in a very high-level usage cases, more than 90% of general practitioners use ICT-based application in healthcare setting in Sweden, the UK, Australia, New Zealand, and the Netherlands [7,8]. This is in part because the paper based system is inadequate to meet nowadays healthcare organization’s need [1] and because ICT-based applications have been recognized as enablers [9,10]. This means that ICT tools offer solutions to the problem of the increasing accumulation of patient data and to day to day clinical work [11-13].

Due to ICT-based applications’ central role in enabling access to information, these applications ensure a more efficient use of healthcare organizations’ scarce resources [14-16]. Increased
efficiency, reduced cost, improved patient care and quality of service, and safety are the factors that healthcare organizations now consider when planning implementing new ICT-based applications [8,17,18]. For example, in particular, Computerized Provider Order Entry (CPOE) system is expected to eliminate ambiguous handwriting, prevent medication and prescription errors, increase efficiency, produce cost saving and ultimately improve patient safety and safety of clinical work [19,20].

1.1 On implementation of HIS

The implementation of Health Information System (HIS)\(^1\) and its processes has demonstrated to be a journey with risks [21]. In spite of the enormous investment in HIS, however, no convincing evidence of their overall benefits has been produced [22]. The outcomes of many HIS implementations in both primary care and hospital settings have either not met all the expectations yet or have failed in their implementation [20,23-27]. Such studies as Ash et al. (2007), Fullerton et al. (2006), and Van Der Meiijden et al. (2003) have indicated undesired consequences [28-30]. Kucukyazici et al. (2008) estimated the failure rate for new HIS implementations in healthcare organizations to be approximately 50% [31].

The implementation of HIS is therefore a major challenge in the healthcare setting. Acknowledgement of this has led to a need for understanding the match between HISs and existing IT infrastructure, organizational structure, and established routines established routine in clinical work and health care organizations. Implementing HISs successfully therefore appears to be a difficult task [32,33]. This means that the decision-making process, leading to the implementation and use of ICT-based applications in healthcare, has to be improved in order to increase the efficiency and the adoption of HIS implementation.

\(^1\) According to Hassett (2002) “a health information system (HIS) encompasses a wide array of applications and information systems that are linked or interfaced. A HIS supports the provision of care to patients and the business aspects of the healthcare organization by communicating information.” [86]
Motivation

1.2 Evaluation of HIS

With the increased spread of ICT-based applications in all healthcare domains from clinical settings to primary healthcare environments, for the purpose of providing an optimal use of resource investment, its use is expected to rise. Evaluating such ICT-based applications to help decision makers acquire knowledge about the impact(s) of ICT-based systems therefore becomes a key issue to all organizations that aim to implement any new ICT-based application [31,34].

HIS evaluation is defined as “the act of measuring or exploring attributes of a HIS (in planning, development, implementation, or operation), the result of which informs a decision to be made concerning that system in a specific context” [6]. There are many reasons why new ICT-based application should be evaluated, e.g. measuring the cost and benefits to the organization and users, justification for the system, selecting among different systems. However, evaluation studies have been slowly growing in medical informatics during the recent years as they are more and more going to be considered part of the planning, development, introduction and operation of information technology in healthcare [12,35]. Meanwhile measuring the outcomes of ICT-based applications becomes actual issues for researchers at the healthcare settings.

In a narrower context, organizational and social issues are the main components of such HIS [36,37], so the more technology, human and organization fit with each other, the greater the potential of HIS. Evaluating such HIS to help decision makers acquire knowledge about the impact(s) of HISs therefore becomes a key issue to all organizations that aim to implement any new application [38,39].

To ensure that newly adopted systems reach their intended goals, managers and decision makers need to develop detailed plans prior to system implementation for post implementation evaluation and examining the use and impacts of the systems. Human and organizational issues are important factors to take into account in the development and implementation of HIS as they have been emphasizing in the literature [36,38]. According to Galliers and
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Leidner (2003) the alignment of technology, human, and organization is considered as a key starting point during information system implementation and as one of the strategies that affect information system implementation [40].

The studies that capture the effects of the implementation and use of ICT-based applications in healthcare may contribute to the emergence of an evidence-based health informatics which can be used as a platform for decisions by policy makers, executives, and clinicians [41]. As information systems are strategically intended to affect organizations, people, and society [21,31], further studies are needed to examine implementations’ effects as well as to identify the factors affecting successful HIS implementation.

2 Aim

The general aim of the work presented in this thesis is to explore and capture issues related to the implementation, use, and adoption of integrated HISs and its consequences for supporting collaborative work in healthcare context. To reach the aim, this thesis has been broken into six research papers with the following objectives:

P1. Methodological approaches employed to capture the effects of HISs’ implementation and use
P2. Challenges and problems involved with the implementation of integrated computerized patient record systems (ICPR)
P3. Key factors which influence the implementation of HISs
P4. Impact of integrated electronic prescribing system on work performance and patient safety
P5. Arisen issues as a consequence of the introduction and use of an integrated electronic prescribing system
P6. Adoption of computerized provider order entry system
Research Objectives

P1. Methodological approaches employed to capture the effects of HISs' implementation and use

With an increased need to implement ICT-based applications in all healthcare domains in order to provide the optimal use of resources and investment, its use is expected to rise. Evaluating such ICT-based applications to help decision makers acquire knowledge about the impact(s) of ICT-based systems therefore becomes a key matter for all organizations that aim to implement them [38]. The aim of this paper is to review published articles about evaluating ICT-based systems in order to gain knowledge about the methodologies used and findings concerning the evaluation of ICT-based systems in healthcare settings.

P2. Challenges and problems involved with the implementation of integrated computerized patient record systems (ICPR)

The productivity of computer-based patient record systems (CPRs) is expected to rise with their increased level of implementation in all healthcare domains [42]. However, the failure rate for new HIS implementations in healthcare organizations has been an important issue in health informatics. The reasons for these failures have been extensively studied and described. However, despite these knowledge information system implementations in healthcare settings continues to fail. The aim of this paper is to examine whether the previously reported problems remain during the implementation of technically integrated and more advanced generations of HISs.
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P3. Key factors which influence the implementation of HISs

Such HISs as CPOE and CPRs have been implemented to enhance the quality of care, to enhance the degree to which it is patient centered, and to improve the efficiency and safety of services. However, the outcomes of HIS implementations have often failed to meet expectations. A number of studies have indicated undesired consequences [30,43]. This draws attention to the urgent need to make the best possible use of the scientific knowledge available about HIS implementation processes and their organizational consequences. The aim of this paper is to organize the knowledge gained by qualitative studies performed in association with HIS implementations and to use this knowledge to outline an updated structure for implementation planning.

P4. Impact of integrated electronic prescribing systems on work performance and patient safety

Electronic prescribing systems are expected to help the prescriber by delivering relevant patient data and information about the pharmaceuticals prescribed. These systems provide opportunities for quality improvement, reduction of errors, and improved workflow efficiency throughout the healthcare sector [44,45]. In Sweden, the introduction of an integrated electronic prescribing system (IEPS) in 2003 was a joint effort between hospitals, primary healthcare centers (PHCs), and the Swedish national pharmacy corporation. The overwhelming majority of previous studies on such systems have focused on outcomes from the healthcare practice perspective. Studies that investigated the pharmacists’ view of electronic prescribing systems are few, at least in Sweden. The aim of this paper is to examine the introduction of an IEPS into pharmacists’ work performance with regard to its impact on efficiency and patient safety.
P5. Arisen issues as a consequence of the introduction and use of an integrated electronic prescribing system

Many studies on electronic prescribing systems have been conducted in previous years, with the aim of showing reductions in various types of medication errors and improved decision-making. These studies, however, generally focused on identifying a limited number of outcomes and specifically focused on how to reduce prescribing errors, often from the doctors’ point of view, or the studies discussed technical aspects of the system. This paper aims to provide an overview of the pharmacists’ staff point of view regarding issues that have been arisen as a consequence of the introduction and use of an IEPS in a Swedish county council.

P6. Adoption of a computerized provider order entry system

In general, the CPOE system has helped healthcare organizations and providers to increase safety, reduce errors, improve workflow efficiency, and increase quality by obtaining relevant patient information and clinical knowledge at the moment of ordering medications [46]. Although the benefits of CPOE systems are widely recognized, few healthcare settings have implemented these systems successfully [47]. Nevertheless, several studies indicate types of unintended consequences related to CPOE system implementation and maintenance [48]. Based on the fact that the use of CPOE involves individuals and depends on organizational context, any organizational plan to implement CPOE system could be expected to have a procedure incorporated for collecting and attending to users’ opinions. In such efforts, it is important to collect and evaluate users’ feedback about the system. In this study, we set out to examine factors associated to the adoption of a CPOE system for inter- and intra-organizational healthcare context.
INTRODUCTION

3 Thesis contribution

Informatics is the understanding of the impact information technology has on people, the development of new uses for technology, and the application of information technology in the context of another field [49]. Informatics lies consequently, at the intersection between people, technology and information systems and it focuses on the ever expanding relationship between information technology and the daily works of people [50]. The subject of informatics is usually consider as inter-disciplinary and focuses, in general, on technical and administrative systems or/and ICT-based applications and methods for computer-aided information.

The work presented in this thesis contributes to increase knowledge in the area of health informatics on how ICT supports inter- and intra-organizational collaborative work in a healthcare context and to identify factors and prerequisites needed to be taken into consideration when implementing new generations of HIS.

4 Methods

The design of any study begins with the selection of a topic and a research methodology. In this thesis both qualitative and quantitative methods were used to be able to capture the effects of the implementation and use of integrated HISs in healthcare organizations as well as to identify the factors influencing HIS implementation.
Methods

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<th>Aim</th>
<th>Method</th>
<th>Data collection method</th>
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<td>Published articles from 2003 to 2005</td>
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<td>II</td>
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<td>Case study</td>
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<td>III</td>
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<td>V</td>
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<td>Questionnaire completed by 63 pharmacists</td>
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Table 1: Overview of included papers in this thesis with their purpose, method, and source of evidence

4.1 Context of the studies

Study context of the papers including in this thesis has been the Östergötland County council in Sweden, where tax-financed healthcare services are provided to the residents by the county council (Table 2).

<table>
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<tr>
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<th>Östergötland county</th>
<th>Linköping</th>
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<tr>
<td>Population</td>
<td>423 169</td>
<td>141 863</td>
</tr>
<tr>
<td>Hospital</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>PHC</td>
<td>42</td>
<td>13</td>
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Table 2: Information about Östergötland county and Linköping (2008)

Sweden has a decentralized healthcare system, with 20 county councils and 290 municipal councils as principals and care providers. Their responsibility as principals includes the provision of adequate
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care services and the requirement to develop, finance, and assure quality of all care activities [51]. In the studied county council (Östergötland) CPRs have been used in primary health care centers and hospitals in the county for more than 10 years [27]. The county council also supplied other types of computer systems to healthcare providers, such as appointment systems, physician-secretary communication systems for dictation, and an electronic prescribing system. However, these systems have not been connected to one another until 2007 to allow the sharing of information and other functions.

Implementation of a new integrated CPR was initiated in 2007 as a pilot project at a healthcare center in the west part of the county, Motala. The implementation process continued from the west part (Motala) to the east part (Norrköping) of the county and was finished by the end of 2008. This new integrated system, developed commercially, provides a comprehensive overview of the patient’s health conditions and care. The system provides an infrastructure for sharing patient data between all healthcare care providers within the county council.

CPOE is one component of the system, which consists of information about patients’ medications and prescription support functions, and is used to send electronic prescriptions. Previously, an electronic prescribing system was available only for the primary healthcare centers. Currently, the integrated system provides all units with CPOE system functions.

The current CPOE system is built up around a common list of medications comprising current and previous prescriptions. When a prescriber prescribes medication or changes dosage, he or she is supported by a central register of medications that is continually updated, with direct reference to national lists of pharmaceutical specialties, brief descriptions of products, instructions issued with medicines, warnings, and recommended and non-recommended medication and prescription templates [52].
The introduction and use of IEPS is a joint effort between hospitals, primary healthcare centers (PHCs), and the Swedish national pharmacy. Conventional prescribing has been considered a process performed on the patient’s behalf that involves considerable time and effort on the part of clinical pharmaceutical actors.

In the Swedish IEPS, an e-prescription is initiated locally through a distributed electronic prescribing network. Only certified prescribing physicians and national pharmacy personnel have access to the prescriptions loaded on the system. To generate an e-prescription, the physician indicates the patient name, the social security number, drug name, and dosage. Each prescription is then transmitted through a secure network to a national electronic prescribing mailbox at the national pharmacy. The patients can choose any pharmacy throughout Sweden to collect their medication.

4.2 Methods used in the papers

Common to studies included in this thesis is to use different sources of data to perform them so called “triangulation”. According to Yin (2008) triangulation is “rational for using multiple sources of evidence” [53]. Triangulation strengthens a study by combining methods such as using several types of methods or data (qualitative and quantitative approach) and also by combining the use of several different researchers [54]. The methodology used in each specific paper is explained as follow:

4.1.1 Paper I: A literature review

In paper I entitled “Methods to Evaluate Health Information Systems in Healthcare Settings: A Literature Review”, a literature review was performed for evaluation studies of IT-based systems in healthcare, including such CPRs as electronic medical records (EMRs) and electronic health records (EHRs), telemedicine, and different kinds of
INTRODUCTION

decision support systems (DSSs) related to information systems, such as CPOE between January 2003 and March 2006. A literature review is an evaluative report of published information in a particular subject area in which should describe, summarize, evaluate and clarify that literature.

Linköping University’s database was used to gain access to papers on this subject, using the keywords ‘patient records’, ‘medical records’, ‘health records’, ‘information technology’, ‘medical informatics’, ‘healthcare information’, ‘health informatics’, ‘hospital information system’, ‘patient care information system’, ‘CPOE’, ‘evaluation methods/theory’, ‘assessment’, ‘appraisal’, ‘information system/technology’, ‘economic evaluation’, and ‘evaluation study’. PubMed, one of the most important databases in health, was also used to search for related papers.

4.1.2 Paper II: An explorative case study

In paper II entitled “Implementing an Integrated Computerized Patient Record System: Toward an Evidence-Based Information System Implementation Practice in Healthcare”, an explorative case study design based on a single case was used for data collection and analysis. Yin (2009) mentions several alternative ways of doing research in social science: experiments, surveys, histories and archival information analysis [55]. Case studies are used in many fields where real-life events and processes are important to capture.

According to Yin (2009), a case study is an empirical inquiry that investigates a phenomenon within its real-life context, where the demarcation between the phenomenon and the context cannot be made clearly evident. Case studies are preferred strategy when “how” or “why” questions are being posed, when the investigator has little control over events - “when the relevant behaviors cannot be manipulated”-, and when the focus is on a contemporary phenomenon within some real-life context. Yin points out those case studies are not
merely a data collection tactic or a design feature but a comprehensive research strategy.

In this study the data were collected during a period of four months in 2007 through interviews and document analyses. In the first step, representatives from all professional categories (one physician, two nurses, one social worker, one administrator, and one pharmacist) using the new ICPR were interviewed by a member of the studied county council. We then conducted 34 interviews to validate our first results. Each interview session lasted about two hours. We also reviewed all documents published by the county council and the local magazines and newspapers that mentioned the system.

In this study, different actors’ perspectives were considered when collecting data and analyzing them. We have used physicians, pharmacist, and nurses and other healthcare staff’s perspectives for our analysis. According to Vimarlund and Olve (2005) and Olve and Vimarlund (2005), ICT is considered as an enabler of improved work practice in organizations. ICT often gives benefit to organizations as well as society through improved services or product quality [9,10]. In healthcare setting, introducing ICT will have effects on healthcare institutions, individuals, as well as patients. Considering different actors’ perspectives are needed to study in order to understand the likely accomplishment of new ICT goals in which it built in the area of health informatics.

4.1.3 Paper III: A qualitative Meta-Analysis

In paper III entitled “Health Information System Implementation: A qualitative Meta-Analysis”, a qualitative meta-analysis was used to identify areas that are commonly known to contain key issues for the implementation of HISs. Specifically, we used the seven-step meta-analysis process introduced by Noblit and Hale (1987), and further developed by Atkins et al. (2008) [56,57]. Over the past two decades, individual qualitative research has been used in many disciplines such as healthcare. Most of these individual qualitative studies are
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discussed in literature reviews in the context of other studies. McCormick et al. (2003) stated that much of these researches are not optimally combined, compared, contrasted, and integrated with other qualitative studies causes failing to meet their full potential for knowledge development and theory building [58].

A qualitative meta-analysis is a type of structured qualitative study that uses as data the findings from other qualitative studies linked by the same or a related topic [59,60]. As noted by Reis (2007) “Although meta-analysis of quantitative research is a well-established technique, the synthesis or aggregation of qualitative studies remain rare and controversial” [61].

In paper III, we included in the analysis qualitative studies published between January 2003 and December 2007 that discussed the effects of the implementation of HIS in hospitals or primary care. We searched the Entrez–PubMed database using the keywords ‘implementation’, ‘HISs’, ‘computer-based/computerized patient records’, ‘electronic medical records’, ‘computerized physician order entry’, and ‘qualitative methods’. We used primarily the evaluation criteria of Aitkins et al. (2008) to assess the identified studies. The final data set was comprised of 17 articles of sufficient quality that addressed factors for the success and failure of the HIS implementation process.

4.1.4 Paper IV and V: A survey research

In papers IV and V entitled, respectively, “Integrated electronic prescribing systems: pharmacists’ perceptions of impact on work processes and patient safety” and “Introduction of an integrated electronic prescribing system: the pharmacies staff view”, a survey questionnaire was developed to capture data relevant for the study. Survey is one of the most common methods to evaluate information systems impact using information from a sample of a population to generalize the results to a population of individuals extending beyond the organizations through a study. A survey or questionnaire is the main data collection method with survey research. Brender (2006)
stated that, “the advantage of questionnaires is that most people can manage to put a questionnaire together to investigate virtually any subject of one’s choice” [62].

A questionnaire with close-ended and open-ended questions with possibility to write free-text was used to collect data in this study. The questions using close-ended and numerical format aimed to identify a) advantages and constraints of the system, b) its potential contributions to increase effectiveness of the work processes and patient safety (reported in paper IV), and c) issues such as trust in the system, safety of the system compared to a paper-based one, impact on customer relations with the pharmacy, and the prevention of errors before delivering the wrong medicine (reported in paper V).

The respondents were requested to categorize their agreement to statements about the IEPS on a five grade scale. To increase the likelihood that the questionnaires would serve their purpose of the study, the face validity of the questionnaires was assessed by a panel of experts, four professionals with backgrounds in health informatics, pharmacology, social medicine, and statistics. The questionnaire then was revised according to their feedback and questions were re-formulated when necessary. The questionnaire was, after validation, distributed in November 2008 to all pharmacies staff (n=85) who were included in this study in Linköping municipality (pop. 145,000), Sweden. In total, 63 out of 85 questionnaires (74%) were returned. Descriptive statistical methods were used to analyze and present the results of the data.

The principles stated in the Technology Acceptance Model (TAM) were used to categorize the results in paper IV. The TAM was developed by Fred D. Davis (1989) to explain computer-usage behavior, using as bases the Fishbein and Ajzen’s Theory of Reasoned Action (TRA) [63]. The goal of TAM is “to provide an explanation of the determinants of computer acceptance that is general, capable of explaining user behavior across a broad range of end-user computing technologies and user populations”. The TAM has been considered as the most influential and commonly applied theory for describing individual user acceptance of information systems by researcher in the
area of information systems [64-66]. The scientific literature has suggested that user acceptance of new information system is the primary and critical factor in information system’s success and adoption (for example see [66,67]). The TAM is based on the factors relating to perceived ease of use of a system, perceived usefulness, behavioral intention to use, and actual system use [63].

This model (TAM) assumes that an individual’s acceptance of an information system is determined by two major factors or variables: “perceived usefulness” and “perceived ease of use”. Where, perceived usefulness is defined as the degree to which a person believes that using a particular system would enhance his or her job performance. Perceived ease of use is defined as the degree to which a person believes that using a particular system would be free of effort. Behavioral intention to use is defined as the individual’s interest in using the system for future work. Perceived usefulness has a direct effect on behavioral intention to use. Perceived ease of use has a direct effect on perceived usefulness and behavioral intention to use. [64]

In paper V Diffusion of Innovation (DOI) theory were used to analyze the result of this paper. (See section 4.1.5 about DOI)

4.1.5 Paper VI: A survey research

In Paper VI entitled “Adopting a CPOE System for Inter- and Intra-Organization Healthcare Communication”, two online survey questionnaires were developed based on DOI theory to capture data from physicians and nurses. Based on DOI theory, the questionnaires asked for data on: a) the demographic characteristics of the study population, b) an overall assessment of the CPOE usage, c) the relative advantages, d) the complexity of the system, and e) the compatibility with users’ values and needs.

The respondents were requested to categorize their agreement to statements about the CPOE system on a five grade scale. To increase the likelihood that the questionnaire will serve its purpose, the face
validity of the questionnaires was assessed by gathering six professionals’ opinions with a background in health informatics, pharmacology, social medicine, economic information system, and statistics. After face validation of the questionnaires, we pilot tested them by 6 physicians and 3 nurses. The questionnaires were revised according to their feedback.

The study population consisted of 741 physicians and 200 nurses in Östergötland county council, Sweden. The division in charge of the CPOE system in Östergötland county council provided e-mail lists of physicians and nurses responsible for CPOE system in their clinics who were using the system.

The questionnaires were distributed in February 2009 through an online survey. The physicians and nurses were contacted by e-mail and asked to complete the questionnaires online, with a reminder e-mail on March 10, 2009. By April 6, we received 41 responses from the physicians and 186 responses from the nurses. To get more responses from the physicians, we tried to concentrate on those who work more with the CPOE system via distribution lists of physicians separated by clinic. We contacted the physicians again by sending the link for the survey to the identified e-mail lists, with a reminder after 2 weeks. Of 200 surveys to nurses, 186 were returned (overall response, 93.0%). Of 741 surveys to physicians, 211 were returned (overall response, 28.5%). However, 52 of the nurses’ questionnaires and 35 of the physicians’ questionnaires were excluded as incomplete. Thus, the total number of questionnaires included was 134 from 200 nurses (analyzed responses, 67.0%) and 176 from 741 physicians (23.8%).

The principles stated in the DOI theory were used to categorize the result of this study. Diffusion has been defined by Everett Rogers as “the process by which an innovation is communicated through certain channels over time among the members of a social system” and an innovation is defined as “an idea, practice, or objective perceived as new by an individual, a group, or an organization [68].

DOI theory outlines five attributes which have been shown to be important in assessing the diffusion potential of an innovation. They
are relative advantage (is it better than the idea it replaced?); compatibility (is it consistent with existing values and needs of users?); complexity (is it hard to understand and use?); trialability (can you experiment with it?); and observability (are results visible to others?). While adoption of any innovation inevitably generated consequences, such consequences can become desirable or undesirable or anticipated or unanticipated [28].

According to Rogers (2003), it is the unintended consequences that are the least studied in an innovation diffusion process. The undesirable, unintended, and unanticipated consequences consists of the adverse events or constrains that have not previously been seen and that have consequence for the effectiveness and efficiency in the use of the system. Once an innovation has been adopted, consequences such as increasing the effectiveness and efficiency will hopefully follow. However, according to Rogers, the consequences of adoption are the least studied aspect of the innovation diffusion process [28]. Many studies have applied DOI theory to study the diffusion and adoption of different kinds of health information systems [28,69,70]. For example, Ford et al. (2008) found that developing a CPOE system that is more user-friendly and easily integrated into hospitals’ legacy systems may be a more expedient approach to achieving widespread adoption. There are thus few studies of unintended consequences related to the implementation of CPOE systems. One exception is Ash et al (2007), who report error and security concerns and issues related to alerts, workflow, ergonomics, and interpersonal relations. They conclude that the DOI theory framework is a useful tool for analyzing consequences of implementing clinical systems which are complex.
5 Results of Papers

The results of this thesis are based on the six papers. In summary, the main results are presented below:

1.1 Result of Paper I

“Methods to evaluate health information systems in healthcare settings: A literature review”


The reviewed literature are presented as a brief description of the names of the authors, the domains the study was performed in, the design of each study, the time of evaluation, the sources of evidence, the aim of the study, and the findings (see paper I).

5.1.1 Evaluation studies’ direction

In our review we found that during the period 2003–2005, most of the evaluation studies included in this paper aimed to include issues such as the effectiveness of the systems, the quality of care, user and patient satisfaction, and the system’s usability (see more details in Table 3).
INTRODUCTION

<table>
<thead>
<tr>
<th>Type of HIS</th>
<th>Evaluation studies’ direction</th>
</tr>
</thead>
</table>
| CPR studies  | - The system usefulness regarding the quality of care  
- User-related issues such as user acceptance and satisfaction and attitudes towards new systems  
- The financial effects, usually limited to the identification of the costs of system implementation  
- The effects of the new system’s implementation on the quality of work performance, such as user job performance and computer knowledge, and investigation of skill among other users |
| Telemedicine studies | - The economic effects of system implementation  
- Effectiveness in the telemedicine area  
- Studies regarding user attitudes and perspectives, user satisfaction  
- The usefulness of the system such as time of service delivery, usability, feasibility |
| DSS studies  | - The usability of systems  
- The effectiveness of the system for patients  
- Financial impacts of introducing the new system  
- Measures of user satisfaction and attitudes towards the system |

Table 3: Direction of the evaluation studies in the reviewed literature

5.1.2 Output of the studies

Introduction and use of the CPR systems was found to have positive effects such as economic benefits, high acceptance score and satisfaction among the users in the implemented sites and also improvements in management and work process.

Moreover, introducing the telemedicine systems was found to have positive effects such as spent time per patient during the visiting by clinical staff, economic benefits, and also quality of care.

Regarding to the DSS’s studies, it can be seen that introducing a clinical DSSs in healthcare organizations had positive effects such as improved quality of care, satisfaction among users in the implemented sites, and also improvements in management and work process.
However, according to this literature review, most of the studies did not discuss a specific theory to be applied when evaluating ICT-based applications in healthcare. Few studies presented discussion of some economic theories such as cost-benefit/effectiveness analysis, and none generated new theories or extended olds ones.

Most of the studies based on the financial model, like cost-benefit/effectiveness, showed that there were improvements with the introduction of the new systems, especially in the telemedicine area. In contrast, some studies showed that the implementation of new DSS or telemedicine had no economic benefits, and few showed that the introduction of the new CPR or DSS were problematic.

The findings also show that economic and organizational aspects dominate evaluation studies in this area. However, the results focus mostly on positive outputs such as user satisfaction, financial benefits and improved organizational work.

### 1.2 Result of Paper II

“Implementing an integrated computerized patient record system: Toward for an evidence-based information system implementation practice in healthcare”


We categorized our finding into three groups those are: medical informatics skills, human–computer interaction, and attitudes and expectation.
Medical informatics skills: The data showed that physicians, nurses, assistant nurses, and front-office staff did not have enough time to practice before “having to swim in the deep [system] end” (Figure 1). The nurses and other non-physician staff were particularly unsatisfied, because they felt that the training sessions were based mostly on physicians’ needs. One of the interviewees gave voice to the common opinion among the staff that:

“The learning materials are hard to understand and tailored to the needs of all specific professional groups, and the practice as a whole”.

It was found that a failure to give all groups of users’ adequate training in using the ICPR negatively impacted the outcome of the implementation process. For instance, because the nurses had not learned to use the system functions properly, they found that the new practice routine was time consuming.

Once the system was implemented, ongoing support was reported to be crucial for the success of the newly implemented system. They asked for the option of further training in order to overcome day-to-day problems.
**Results of Papers**

- Complex system architecture
- Time consuming to log onto the system and call up patient files
- Time consuming to learn and use new words, terms, concepts, and connotations

**Figure 2**: Display of the first-order analysis results related to human–computer interaction

**Human–computer interaction**: The first technical problem was that logging on to the integrated system was perceived as consuming too much time. Then, after logging on to the system, several functions were found to be unintuitive and not user-friendly, causing dissatisfaction and disappointment (Figure 2).

With the new system, calling up a specific file consumed more time than the previous system. The integrated system also required use of new terms and concepts, and the users emphasized that learning these took time.

**Figure 3**: Display of the first-order analysis results related to attitudes and expectation

- Transparent plan and budget missing
- Involving users in system design
- Involving users in system implementation
- Defining new work routine before implementation
- Enough incentive and motivation

**Design** | **During implementation** | **Post implementation**
Attitudes and expectation: In the case study setting, the users expressed that more user participation in the design and implementation phase of the system would have provided a better fit into workflows and work practices (Figure 3). There was a general unwillingness to adapt clinical routines to the new system. The main adjustment of the implementation process that the users – especially physicians – asked for was “more involvement in the decision procedures”.

More user involvement would both have helped define the system requirements in more detail and revise work practices to better integrate the new system.

The respondents also made complaints about the timing of the implementation at the pilot site. They felt that the policy-makers had decided to implement the system in too short a time period, causing problems with adjustments, mainly in learning terms and navigation routines.

Another concern among the practitioners was whether the general implementation plan was realistic, i.e. included adequate labor and financial resources.

1.3 Result of Paper III

“Health information system implementation: A qualitative meta-analysis”


A multi-disciplinary team (a PhD student in health informatics with health services management background, a PhD in the area of economic information system, and a PhD in health informatics with
medical doctor background) performed the qualitative meta-analyses in order to cover as many aspects of the primary studies as possible.

In the synthesis, eleven areas were identified as being important for the implementation of HISs. These areas can be divided into three domains with regard to the time span of the decision-making process:

| a) The long-term strategic domain: management involvement, motivation and rationales, surveillance of system effectiveness, and information needs assessments. |
| b) The medium-term tactical domain: education and training support, the implementation process and methods, work routine and workflow integration, and system integration. |
| c) The day-to-day operational domain: trust, user participation and involvement, and technical system performance. |

*In the long-term strategic domain*, HIS implementation was found to require careful planning from management and continuous supply of information about the system performance. Similarly, when organizational objectives are altered, there is a need to adjust the implementation plans accordingly. Moreover, making room for continuous improvement was found to be important not only during the de facto HIS implementation, but also after the system had been formally introduced in order to maintain optimal system performance. If the management underestimates the complexity of clinical routines and the importance of end users being involved in the implementation process, inefficiencies can result that affect the organizational performance of the HIS and staff confidence in the system.

*In the medium-term tactical domain*, it was found that views on how to fit the system into the clinical workflow often differed, with systems developers and managers on one side, and clinical teams on the other. To implement a ‘general-purpose’ HIS that meets the needs
of both clinical planning and patient practice is problematic. Since the strengths and weaknesses of a system implementation depend upon the value they offer to end users, important trade-offs between tasks and user groups must be carefully considered.

*In day-to-day operation domain,* resistance was observed, in cases where the clinicians had been involved in the design and implementation process as opinions regarding the usability of the new system differ between stakeholders and practitioners. Consequently, harmonization between organizational and individual clinical goals in day-to-day practice was found to be crucial to successful implementation.

Another critical factor associated with successful clinical system implementation was found to be participation and collaboration across user groups. Professionals from medicine, nursing, and laboratory disciplines have to learn to collaborate in an HIS environment and acquire personal experience concerning the reliability of the system functions like e-prescriptions and networked image management. Otherwise, a perception that technical system deficiencies reduce the quality of clinical routines can result, which is counter-productive to increasing the effectiveness of the clinical services.

### 5.3.1 Implications for Implementation Planning

When implementing HISs in hospital and primary care environments, the results of the meta-analysis suggest that, at a minimum, the following strategic, tactical, and operational actions should be taken into consideration.

#### 5.3.1.1 Strategic Actions

*Management involvement:* The roles of managers in HIS implementation should include developing an understanding of the capabilities and limitations of the HIS, establishing reasonable goals for the HIS, exhibiting strong commitment to the successful
introduction of HIS, and developing and communicating the IT strategy to all clinical staff. In addition to this, it is necessary to allocate resources to the implementation efforts and to clearly define short-term and long-term goals for the HIS and the organization.

5.3.1.2 Tactical Actions

HIS integration in healthcare workflow: The system implementation must be performed using a re-engineering approach. Re-engineering in this context means considering the extent to which hospitals and primary care organizations need to adjust their work processes in order to optimally utilize HIS functions. Operational processes help accomplish typical clinical functions, such as medical services and patient support. Infrastructural processes are more administrative, for example, establishing and implementing strategy and managing human resources, physical assets, and information systems. The HIS should be integrated into both these types of processes.

5.3.1.3 Operational Actions

User involvement: When participating in the system implementation, the users should be allowed a transition period that gives them time to understand and appreciate the outcome of the system implementation.

Establishing compatibility between software and hardware: Management and systems developers must choose HIS software that matches the legacy systems, for example, the hardware platform, databases and operating systems.

Education and training: Hospitals and primary care organizations can only benefit from HIS implementations if their staffs utilize the system. For this reason, factors that encourage individuals to use the HIS, such as adequate education and training, also impact organizational performance when the system is implemented.
1.4 Result of Paper IV

“Integrated electronic prescribing systems: pharmacists’ perceptions of impact on work performance and patient safety”


The principles stated in the TAM were used to categorize part of the result of this study. The results were structured by analysis area (Demographic characteristics, IEPS usefulness and ease of use, IPES impact on patient safety, IEPS advantages, and development possibilities) and professional category (pharmacists and pharmacist’s assistants).

Faster processing of prescriptions was the most appreciated contribution of the IEPS, with a mean score of 4.63 (95% CI, 4.48–4.78) for the pharmacists and 4.45 (95% CI, 3.99–4.92) for the pharmacist’s assistants. The other main contribution was that the system was perceived to make the work easier than when using the previous paper-based routines: mean score 4.47 (95% CI, 4.27–4.68) for pharmacists and 4.55 (95% CI, 4.19–4.90) for pharmacist’s assistants (Figure 4).
The capability of the system to support all types of prescribing was perceived as a less important contribution to enhance job performance: mean score 3.59 (95% CI, 3.27–3.91) for pharmacists and 3.45 (95% CI, 2.76–4.15) for pharmacist’s assistants.

Other lower ranked contributions included the capability of the system to reduce calls due to prescription ambiguity: mean score 3.73 (95% CI, 3.40–4.05) for pharmacists and 3.91 (95% CI, 3.35–4.47) for pharmacist’s assistants.

The respondents generally indicated that the risk for prescription errors was reduced by using the system: mean score 3.83 (95% CI, 3.53–4.11) for the pharmacists and 4.09 (95% CI, 3.62–4.56) for the pharmacist’s assistants (Figure 5).

There was a tendency for the pharmacist’s assistants to be more positive towards the safety features than the pharmacists, especially regarding the “trustworthiness of the prescription” mean score 4.00
(95% CI, 3.48–4.52) among pharmacist’s assistants and 3.67 (95% CI, 3.44–3.90) for pharmacists and making it possible to correct prescription errors: mean score 3.91 (95% CI, 3.35–4.47) among pharmacist’s assistants and 3.51 (95% CI, 3.42–3.80) for pharmacists (Figure 5).

![Figure 5: Perceived effects of the use of electronic prescribing on patient safety (scale 1 = low contribution to 5 = high contribution).](image)

28.8% of pharmacists and 18.2% of pharmacist’s assistants reported that the introduction of the IEPS had proceeded very well in their work setting, while the remaining respondents reported that the system introduction had gone well. None of the respondents indicated that the introduction had progressed badly.

Both pharmacists and pharmacist’s assistants reported that forgery risk and the risk for confusion of patients or drugs had declined by using the new IEPS (Table 4).
According to the respondents, the main area where the IEPS could be further developed is the loss of working hours due to computer-related problems. Also, a relative helplessness related to a general dependency on computers was indicated as a problem (Figure 6).

We found that, in general, the IEPS was perceived to have expedited the processing of prescriptions and reduced the risk for prescription errors, as well as the handing over of erroneous medications to patients. Pharmacists were more cautious about the residual risks for making mistakes than the pharmacist’s assistants.
INTRODUCTION

1.5 Results of Paper V

“Introduction of an integrated electronic prescribing system: The pharmacies staff view”


The aim of this paper is to provide an overview of the pharmacists’ point of view regarding issues that have arisen as a consequence of the introduction and use of an IEPS in a Swedish county council.

About two-thirds of the pharmacists (63.5%) and more than one-half of the pharmacist assistants (55.6%) reported that they trust the IEPS (Figure 7). However, 3.8% of the pharmacists did not trust the IEPS.

![Figure 7: Distribution of Respondents’ Answers about Trust in IEPS.](image-url)

The respondents’ answers to questions related to safety issues showed that 82.7% of the pharmacists and 77.8% of pharmacist assistants agreed that e-prescriptions are safer than paper ones. Only 7.7% of the
pharmacists did not agree that e-prescriptions are safer than paper ones (Figure 8).

Figure 8: Distribution of Respondents’ Answers about Whether E-Prescriptions Are Safer Than Paper Prescriptions.

Figure 9 shows that 48.1% of the pharmacists and 44.4% of the pharmacist assistants stated that their contact with prescribers decreased after implementation of the IEPS. However, 40.4% of the pharmacists and 22.2% of the pharmacist assistants reported that their contact with prescribers has not changed. It is interesting to note that only 5.8% of the pharmacists indicated that their contact with prescribers increased.
INTRODUCTION

Respondents who stated that their contact with prescribers had changed (either increased or decreased) were further asked how the IEPS affected the quality of contact with prescribers. Pharmacists (83.9%) and pharmacist assistants (50%) reported that the increase or decrease in contact was positive. Only 6.5% of the pharmacists considered the change in level of contact as negative (Figure 10).

Figure 9: Distribution of Respondents’ Answers about How Contact Between Pharmacists and Prescribers Has Changed.

Figure 10: Distribution of Respondents’ Answers about How the IEPS Has Affected the Quality of Contact with Prescribers, if the IEPS Changed the Level of Contact.
In general, most pharmacists and pharmacist assistants reported that pharmacy customers were satisfied with using the IEPS. All pharmacist assistants and 76.9% of pharmacists reported that customers seemed to be satisfied after the introduction of the IEPS. Only 3.8% of the pharmacists stated that customers were dissatisfied (Figure 11).

![Figure 7: Distribution of Respondents’ Answers about the Level of Satisfaction for Pharmacy Customers since the Introduction of the IEPS.](image)

About one-third of the pharmacists (36.5%) and pharmacist assistants (33.3%) reported that the IEPS helped them prevent medication error before the error reached the patient. Specifically, 36.5% of the pharmacists and 33.3% of the pharmacist assistants reported that, during the last 10 days, the IEPS enabled them to prevent medication errors. However, 63.5% of the pharmacists and 66.7% of the pharmacist assistants indicated that, during the last 10 days, the system did not contribute to preventing specific errors of this type (Figure 12).
All of the pharmacist assistants and (78.4%) of the pharmacists reported that over the last 10 days, when they were using the IEPS; the use of system did not cause any medication error. It is important to note that 21.6% of the pharmacists stated that using the system caused medication errors (Figure 13).

Figure 12: Distribution of Respondents’ Answers About Whether Using the IEPS in the Last 10 Days Prevented Medication Errors Before the Error Reached the Patient.

Figure 13: Distribution of Respondents’ Answers about Whether Use of the IEPS Caused an Error in Medication.
Most of the pharmacists (96.1%) and (66.7%) of the pharmacist assistants stated that they do not want to return to the paper prescription system. It is, however, important to note that 2.0% of the pharmacists and 11.1% of the pharmacist assistants would like to return to the paper prescription system (Figure 14). For instance, some arguments were: “It is easier to monitor and read from a paper prescription rather than from the computer screen” or “It is simpler for [the] pharmacist assistant to get the prescription by paper.”

![Figure 14: Distribution of Respondents' Answers about Their Preference to Return to the Paper Prescription System.](image)

In the free-text section, the respondents raised questions related to issues or problems that apparently were resolved as a consequence of the implementation and use of the IEPS. Some examples of what they considered as important issues are shown in Table 5.
INTRODUCTION

Pharmacists

- Legibility was increased
- Forgery risk has decreased
- Improved patient safety
- Drug overusing has decreased
- Faster expedition time rather than previous one
- Decreased telephone prescription
- Customers cannot take double prescription
- Time saving for patients
- The risk of confusing of prescribing between drugs has decreased

Pharmacist assistants

- Legibility was increased
- Forgery risk has decreased
- Increases patient safety
- Drug overusing has decreased
- Faster expedition time rather than previous one

Table 5: Free text voices related to resolved problems after IEPS

Increasing the legibility of prescriptions was one of the most important impacts of implementation of the IEPS common to both groups. Use of the system decreased the occurrence of unclear prescribing, as sometimes they could not read even the prescriber’s name in the paper-based prescription and diminish of risks for drug overusing were also identified as important outputs. Pharmacists pointed out even other issues as important such us decrease telephone prescription, prevention of double prescriptions and risk for confusing drugs.

The free-text comments showed however, that some new problems appear related to the IEPS were of importance for these professional groups. Examples issues the respondents considered important are shown in Table 6.
One of the most important issues identified for both groups was the fact that computers sometimes disconnect in the pharmacies. Another important comment was that it takes time to correct a wrong prescription and that sometimes the system works very slowly. Specific and even more important is the opinions of the pharmacists. They pointed out extremely important issues for patient safety. Namely the fact that doctors cannot cancel the order they have sent to the pharmacy and that sometimes they receive many similar prescriptions or that due to similarity of drugs names or codes mistakes occurs.

Finally, the respondents indicated general suggestions about how to improve the system. Some of the most relevant improvements they identified are shown in Table 7.
### Table 7: Free text voices from end users about the general suggestions on how to improve the IEPS

<table>
<thead>
<tr>
<th>Role</th>
<th>Suggestions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pharmacists</td>
<td>- Giving prescribers the opportunity to cancel or change their ordered prescriptions in case of double or wrong prescriptions.</td>
</tr>
<tr>
<td></td>
<td>- Giving patients the opportunity to check the status of their prescription(s) on the Web.</td>
</tr>
<tr>
<td></td>
<td>- Periodically updating the pharmacies’ computers and the IEPS.</td>
</tr>
<tr>
<td></td>
<td>- Giving pharmacists the opportunity to take a short training course to learn how the physician order entry system works.</td>
</tr>
<tr>
<td></td>
<td>- Using the same system or at least the same catalogue list with the same abbreviations for dosing (for example, the name of a medicine or instructions for injection) in both prescribers and pharmacists.</td>
</tr>
<tr>
<td></td>
<td>- Providing sufficient user training to prevent mistakes and decrease calls from pharmacies to the prescribers.</td>
</tr>
<tr>
<td>Pharmacist assistants</td>
<td>- Using the same system or at least the same catalogue list with the same abbreviations for dosing (for example, the name of a medicine or instructions for injection) in both clinics and pharmacies.</td>
</tr>
</tbody>
</table>
1.6 Result of Paper VI

“Adoption of computerized provider order entry systems: An organization-wide study based on diffusion of innovations theory”


The characteristics of respondents participating in this study can be seen in Table 8.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Physicians (n=176)</th>
<th>Nurses (n=134)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sex</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>98 (55.7%)</td>
<td>13 (9.7%)</td>
</tr>
<tr>
<td>Female</td>
<td>78 (44.3%)</td>
<td>121 (90.3%)</td>
</tr>
<tr>
<td><strong>Age groups</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20-29 y</td>
<td>9 (5.1%)</td>
<td>3 (2.2%)</td>
</tr>
<tr>
<td>30-39 y</td>
<td>40 (22.9%)</td>
<td>34 (25.4%)</td>
</tr>
<tr>
<td>40-49 y</td>
<td>49 (28.5%)</td>
<td>42 (31.3%)</td>
</tr>
<tr>
<td>50-59 y</td>
<td>53 (30.3%)</td>
<td>44 (32.8%)</td>
</tr>
<tr>
<td>&gt; 60 y</td>
<td>24 (13.7%)</td>
<td>11 (8.2%)</td>
</tr>
<tr>
<td><strong>Workplace</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary health care center</td>
<td>43 (24.4%)</td>
<td>9 (6.7%)</td>
</tr>
<tr>
<td>Hospital</td>
<td>133 (75.6%)</td>
<td>117 (87.3%)</td>
</tr>
<tr>
<td>Home care</td>
<td>0</td>
<td>8 (6.0%)</td>
</tr>
<tr>
<td><strong>County district</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Central</td>
<td>102 (58.0%)</td>
<td>86 (64.2%)</td>
</tr>
<tr>
<td>East</td>
<td>36 (20.5%)</td>
<td>26 (19.4%)</td>
</tr>
<tr>
<td>West</td>
<td>38 (21.5 %)</td>
<td>22 (16.4%)</td>
</tr>
<tr>
<td><strong>Time of CPOE system use</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 6 months</td>
<td>47 (26.7%)</td>
<td>43 (32.1%)</td>
</tr>
<tr>
<td>6-12 months</td>
<td>34 (19.3%)</td>
<td>47 (35.1%)</td>
</tr>
<tr>
<td>&gt; 1 year</td>
<td>95 (54.0%)</td>
<td>44 (32.8%)</td>
</tr>
<tr>
<td><strong>Number of orders in a normal day</strong></td>
<td></td>
<td></td>
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<tr>
<td>&gt; 20</td>
<td>45 (25.6%)</td>
<td>51 (38.1%)</td>
</tr>
<tr>
<td>10-20</td>
<td>76 (43.2%)</td>
<td>27 (20.1%)</td>
</tr>
<tr>
<td>&lt; 10</td>
<td>55 (31.2%)</td>
<td>56 (41.8%)</td>
</tr>
</tbody>
</table>

*Table 8: Characteristics of respondents participating in this study*
About one-half of the nurses (76, 56.7%) and one-third of the physicians (55, 31.3%) stated that the system’s introduction had worked well (good or very good) in their clinical setting. About three-quarters of the physicians (130, 73.9%) and one-half of the nurses (68, 50.7%) reported that they found the system not adapted to their specific professional practice. Nevertheless, about two-thirds of the nurses (93, 69.4%) and the physicians (107, 60.8%) stated that they did not want to return to the previous paper-based system, in contrast to the 44 physicians (25.0%) and 18 nurses (13.4%) who stated that they did want to return to the previous system.

When comparing the composed index for the three attributions of the diffusion of innovation theory (Figure 11), we found that the relative advantages of the CPOE system was 39.6% among nurses and 16.5% among physicians. However, physicians’ agreements with the compatibility of the CPOE and with its complexity were respectively 38.1% and 39.2%.

![Figure 11: Overall level of CPOE compatibility, advantages and complexity](image)

Many physicians and nurses agreed that the CPOE system provides access to a public list of medicines (respectively, 62.5% and 61.2%), provides adequate support in prescribing oral medicine (respectively, 57.4% and 60.4%), and provides clinically relevant alerts for drug
interactions (respectively, 47.7% and 49.3%). However, only 5.7% of the physicians and 9.7% of nurses agreed that the system provides adequate support in prescribing medication by infusion, and only 15.3% of the physicians and 25.4% of the nurses agreed that the system provides an opportunity to change, suspend, and terminate medication regimens (Figure 12).

The respondents offered diverse opinions about the relative advantages of the CPOE system on work efficiency and patient safety (Figure 13). Most of the physicians (65.3%) and nurses (40.3%) agreed that the system was faster to handle than the paper-based system. The physicians (54.5%) and nurses (72.4%) agreed that the system increased the legibility of the data (prescriptions). In addition, 54% of physicians and 70.1% of the nurses agreed that the system contributed to better information exchange between different caregivers.

A low percentage of the physicians (18.2%) and nurses (25.4%) agreed that the system saved time for staff. Regarding patient safety,
few of the respondents agreed that the system reduced the risk of medication error (22.7% of the physicians and 32.1% of the nurses) and that the system helped to achieve a high level of patient safety (22.7% of the physicians and 38.8% of the nurses).

Figure 13: Distribution of respondents’ agreement about relative advantages of the CPOE system

Figure 13 shows, to some extent, differences between physicians’ and nurses’ views of the relative advantages of the CPOE system. For example, most physicians and nurses agreed about increased legibility of data and improved information exchange between different caregivers through use of the system. Nevertheless, Figure 13 also shows that fewer physicians than nurses agreed that the system saves
time for them and that a high level of patient safety was achieved by using the system.

Most physicians (82.4%) and nurses (82.8%) agreed that the CPOE system increased computer dependency. In addition, 67% of the physicians and 61.2% of the nurses agreed that the system lead to computer-related problems (software and hardware), which impacted on time use. The physicians (50%) and nurses (41%) agreed that the system raised doubts about reliability/completeness of data (Figure 14). Of note, 30.7% of the physicians and 30.6% of the nurses agreed that the system introduction led to more adverse drug events.

![Figure 14: distribution of respondents’ agreement about complexity of the CPOE system](image)

Based on Figure 14, we can see consistency between physicians and nurses’ agreement on issues such as increased computer dependency and questions about the reliability/completeness of data by using CPOE system.
6 Discussion

In our literature review (paper I) we found that during the period 2003–2005, most of the evaluations aimed to include issues such as the effectiveness of the systems, the quality of care, user and patient satisfaction, and the system’s usability. The evaluation studies tended also to use subjective approaches combined with quantitative studies in order to analyzing cost and benefits. Survey, clinical trial, and financial analysis were uses as research method in most of the reviewed studies. A key requirement for analytical work is a clear definition of what constitutes an ICT-based application. Today there are different terminologies relating to similar systems. Analysis of the effects has predominantly taken place at an organizational level. However, this does not take account of the differences in the settings in which analysis is taking place.

It has been difficult to find generalized models and methods to evaluate ICT-based applications in clinical settings that cover all such aspects as economic and both inter-organizational and intra-organizational approaches. The results reported in the paper I showed that no standard framework exists for evaluating or developing evaluations methodology in order to obtain clear and more exact feedback about the implemented systems’ effects, or about the impact(s) of implementation and the use of ICT in healthcare settings. The results showed that no previous studies have explored the impact(s) of ICT on the healthcare systems’ productivity and effectiveness.

A significant barrier to investment in ICT in healthcare is the widely recognized fact that any cost saving resulting from technology changes is not always seen by the implementer, but is rather passed on to a third party. In essence, benefits appear at one site and in one budget, while a large share of the cost commitments appear at another site and in another budget. To our best knowledge, the evaluation studies performed do not include any discussion about this important issue, or how lack of incentive to adopt systems can influence the organization and its personnel.
Further, the potential effects of the implementation of ICT-based applications are identified without analyzing them from an inter-organizational and economic perspective.

The paper II comparisons with the literature review found both a recurrence of previously reported implementation problems and the development of new issues specific to the integrated system context. Possibly, the most important challenge in the case study setting concerned the way in which the ICPR implementation process could be adapted to the needs of different user groups. The second important challenge associated with it was the human-computer interaction consequences of the large-scale technical integration of sub-systems into a homogenous infrastructure. In this study re-experiences of known implementation problems were found. The fact that users’ training was based on physicians’ needs and not adjusted to nurses and other non-clinicians. This is one of the major sources of complaints. From the case study setting, requests were expressed for user involvement in the design and implementation phase of the system, in order to provide better insights into existing workflows and work practices.

The paper III found that merely implementing an HIS does not automatically increase organizational efficiency, and that healthcare organizations need methods and structures that can be used to avoid a mismatch between HISs, organizational characteristics, and both their internal and external processes. There are a number of major issues that lead to inefficiencies in the present implementation practice. These issues start with the lack of understanding among managers of what users need, and expand to include the implementation of HIS, the design or functionality of which does not support organizational workflow or users’ work routines. The results also highlighted the need to domesticate and integrate new HISs into organizations’ daily work practices. Therefore, the use of approaches that accelerate the acceptance of the technology and consequently its integration into daily work routines should be emphasized during the implementation process.
In paper IV, we found that the respondents perceived that the IEPS had improved their job performance, and evaluated the system as being easy to use in their day-to-day routines. Electronic prescribing systems can contribute to increased workflow efficiency and the availability of complete data throughout the drug prescription management process, better access to patient data, and safer than the manual management of prescriptions. We also found a general perception of increased patient safety and decrease in medication and prescription errors. However we observed more remaining concerns about patient safety when using the new system. However, it seems that the system does not avoid all mistakes or errors and medication errors still occur. However, we can observe similarities with a previous study that showed that certain errors are facilitated by using this kind of computerized system [71].

Trust in the HIS increases when the system is integrated into the user’s daily work. In paper V, we found that one of the most relevant findings was that most of the personnel trust the IEPS. The electronic prescription is a major breakdown in physician-pharmacist communication. We found that communication between pharmacists and the prescribers changed due to introduction of the IEPS. Even if respondents did not consider this to be negative, this is still an important issue to consider in the future. In this study, even though benefits were gained with the use of an IEPS, the respondents still reported that computer-related problems have increased. The need for sufficient technical support and an effective user interface are essential factors in this context.

The respondents in general seem to be positive to the new system when analyzing the quantitative answers (paper IV). However, at the same time in the qualitative data, they also indicate important errors, and sources of inefficiency those are important for patient safety and work processes. In paper V, besides finding an adoption of the IEPS, we identify a series of undesired and non planned outputs that affect the efficiency and efficacy of use of the system. While adoption of innovations such as the IEPS almost inevitable generated consequences, this study showed that such consequences refers to events that were not anticipated or specific associated with the project.
Finally, despite the fact that not everything is perfect, the results of this study have shown that there are more positive than negative outputs from using the system.

In paper VI, we found that three-quarters of physicians and one-half of nurses found that the system was not adapted to their specific professional practice. This pattern is not surprising in light of previous research and due to the fact that CPOE systems are mainly designed to support physicians’ clinical decision-making, while supporting nurses in administering these decisions to patients. The results of this paper indicate that an important reason behind the reluctance of physicians and nurses to use the CPOE system was that the system was not adapted to their work routines. In the study setting, the respondents seemed to be negative towards the CPOE system due to productivity losses, for example, as consequences of human-computer interaction problems. Research has shown that CPOE systems can increase productivity by making it possible to execute orders faster and easier than using paper technology [72-74]. However, the results of our study showed that most physicians and the nurses disagreed that the system saved time for them and was as easy to manage as paper documents. Although prescriptions may have taken more time per order using the CPOE system than paper, time can be saved during sequential tasks, for example, by being able to review the orders without having to use paper [75]. Such an interpretation is supported by the fact that a majority of the physicians and nurses in our study did not want to return to paper documents.

Moreover, patient safety has been identified as one of the most important advantages of CPOE systems (paper IV). The safety effects have been reported to be mediated through two mechanisms, avoidance of mistakes (increased prescription legibility and possibility to correct misunderstandings) and support for evidence-based prescriptions [44,76].

A CPOE system with integrated clinical decision support can be an advantage for the busy clinician who must combine and manage an increasing body of clinical knowledge. However, such support will not be optimal if clinicians begin to trust these systems without
questioning the assistance [48,77]. Recent research on safety in man-machine interaction suggests that the presence of environmental cues reflecting hazards increases alertness among decision-makers and reduces the risk of mistakes [78]. From this perspective, it is positive that the system users had doubts about the reliability and completeness of the support provided by the system. Alertness is particularly important in light of the results of several previous studies that reported CPOE systems led to a number of errors and adverse drug events [79-81]. In fact, about 30% of the physicians and nurses in our study indicated that the system could lead to more adverse drug events.

7 Conclusion Remarks and Future Work

The studies in this thesis were related to the topic of factors that influence the implementation and use of integrated HISs in inter- and intra-organizational healthcare context. The reason to focus on this topic was that, though there had been a strong increase in implementation and use of information systems in healthcare setting, issues such as adoption, HISs effects, and factors influencing the implementation and use of integrated HISs still need to receive more attention. Publication of such studies contributes to the emergence of an evidence-based health informatics which can be used as a platform for decisions by policy makers, executives, and clinicians.

Based on the result from paper I, it can be concluded that there is an increasing need to share knowledge and to find methods for evaluating the impact of investments and formulating indicators for success. It is therefore interesting to develop or extend evaluation methods that can be applied to this area with a multi-actor perspective in order to understand the effects, consequences, and prerequisites for the successful implementation and use of ICT in healthcare.
It can be concluded that (based on the second paper II’s results) HISs, particularly ICPRs, be introduced to fulfill a high number of organizational, individual-based, and socio-technical goals at different levels. It is therefore necessary to link the objectives that these systems are designed to achieve with organizations’ short-term, middle-term, and long-term strategic goals. Another conclusion is that implementers and vendors have to direct more attention to what has been published in the area to avoid more failures in the future. The third conclusion is that if we want more evidence-based practice, we need more practice-based evidence.

However, practical experience reveals the gap that still exists between anticipated system effects and real world outcomes. Based on (paper III), approaches from different disciplines (economic information systems, health management, and health informatics) have been used to examine the processes by which HIS adoption occurs, identifying barriers to implementation success, and suggesting strategies to avoid or to resolve these problems. When implementing HISs in hospital and primary-care environments, the results of the paper III’s meta-analysis suggest that such strategic actions as management involvement and providing sufficient resource allocation, such tactical actions as HIS integration in healthcare workflow, and such operational actions as user involvement, establishing compatibility between software and hardware and education and training should be taken into consideration.

There are, however, inherent challenges associated with the synthesis of qualitative research, for example, the studies included in the analysis may draw upon different theoretical underpinnings, ranging from ethnography to phenomenology. This means that it is not a straightforward process to critically appraise the quality of the primary texts using only general guidelines. Every effort was made to be as rigorous as possible by focusing the research questions and inclusion norms in order to set well-defined boundaries for our meta-analysis in paper III.

The study of the IEPS has shown that the introduction of any new information system in a healthcare setting may always creates
opportunities for error; e.g., through the human-machine interface as keystroke errors. Therefore, it is important that all types of errors are monitored and attended to. Even though benefits were gained with the use of an IEPS, the respondents still claimed that computer-related problems had increased. The benefits of an IEPS will only be fully gathered if the provider organization chooses a system that has the appropriate features.

It seems rational to expect that decision makers, when making plans or developing strategies for changes, take into consideration even elementary problems such as upgrading the pharmacies’ computers and servers, choosing appropriate technological infrastructure, and ensuring interoperability with existing systems. Such issues decrease the acceptance and use of any new systems because of their impact on perceived usefulness, perceived ease of use of the system, and users’ satisfaction with the system.

The main perceived advantages of the IEPS were increased safety, smoother prescribing, better service to the patients and timesaving for all parties. Parallel use of paper-based prescription requires upholding of two parallel practices. We therefore suggest diminishing, or even totally eliminating, paper-based prescription when an IEPS is introduced. It is also crucial to continually collect and evaluate pharmacists’ and physicians’ feedback about the system. Thus, any organizational plan to implement computerized order entry and computerized prescribing should have a procedure incorporated for collecting and attending to users’ opinions.

It is also interesting to note that we identified a series of undesired and non-planned outputs that affect the efficiency and efficacy of use of the system. While adoption of innovations such as the IEPS almost inevitable generated consequences, this study showed that such consequences refers to events that were not anticipated or specific associated with the project. We identified issues that were not directly related to the system as a system and pointed out issues that were identified as a consequence of the diffusion of the system in an inter-organizational level and that to a great extent depends on issues
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related to security and control more than to system performance, usability or architecture.

When developing a clinical computer system that users interact with in their daily practice, consideration of the users’ professional requirements must be at the core of the system implementation process [68,69].

The risks of ineffective implementation and adoption of HISs such as CPOE systems are high, as well as the risk for unintended consequences [19,82]. The importance of understanding the concerns of CPOE system users is highlighted. In our studies regarding IEPS and CPOE, respondents were worried that the system was not adapted to their professional practices. As any future change in health setting is usually faced with some problems and challenge and resistance [83-85], we conclude that the system designers and healthcare decision-makers should continually collect users’ feedback about the system. It is also necessary to educate users of the health information system on potential benefits and changes involved.

HIS is considered as the solution for the limitations of ‘traditional’ means. As a consequence, the expectations of users are often very high. It can be concluded that building integrated HIS, requires systems that have rather significant additional advantages compared to traditional means [19,82]. What can be concluded from the results mentioned above is that the adoption of integrated HIS should be considered as an important step and concern when decisions are made in the initial phase of its introduction. So designing both formative and summative evaluation using quantitative and qualitative method is necessitated.

It can be concluded that, in the future, when analyzing and performing a broader evaluation of an integrated HIS adoption - the effects of changed work processes for groups of professionals those interact with each other and that need to integrate part of their work processes to offer better service to their patients- it will be necessary to pay
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attention towards individual, managerial, organizational, and social issues.
8 References


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Linköping Studies in Statistics


Linköping Studies in Information Science


