

# **Supporting Collaborative Work through ICT**

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

**Bahlol Rahimi**

Printed by LiU-Tryck, Linköping 2009-09-09  
ISBN: 978-91-7393-550-0  
ISSN: 0345-7524  
Cover design by Ali Ardi  
© Bahlol Rahimi, 2009

*Tanrının Adı ve Şadile*

*To*

*Setareh  
Kiarash*

*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.

- I. Rahimi, B., and Vimarlund, V., Methods to evaluate health information systems in healthcare settings: A literature review. *Journal of Medical Systems*, 2007, 31(5), p.397–432.
- II. Rahimi, B., Moberg, A., Timpka, T. and Vimarlund, V., Implementing an integrated computerized patient record system: Toward for an evidence-based information system implementation practice in healthcare. In *American Medical Informatics Association (AMIA) Annual Symposium Proceeding*, November 8-12, 2008, Washington DC.
- III. Rahimi, B., Vimarlund, V., and Timpka, T., Health information system implementation: A qualitative meta-analysis. *Journal of Medical Systems*. 2009, DOI 10.1007/s10916-008-9198-9
- IV. Rahimi, B., Vimarlund, V., Mokhtari, R., and Timpka, T., Integrated electronic prescribing systems: pharmacists' perceptions of impact on work performance and patient safety. In the *9th WSEAS International Conference on Applied Informatics and Communication (AIC'09) Proceeding*, August 20-22, 2009, Moscow, Russia.

- V. Rahimi, B., and Vimarlund, V., Introduction of an integrated electronic prescribing system: The pharmacies staff dimensions. In the 14th International Symposium for Health Information Management Research (ISHIMR) Proceeding, 14-16 October 2009, Kalmar, Sweden. (In press)
- VI. Rahimi, B., Vimarlund, V., Timpka, T., Svensson, M., and Srinivas, U., Adoption of computerized provider order entry systems: An organization-wide study based on diffusion of innovations theory. Submitted to BMC Medical Informatics and Decision Making journal.

## Acknowledgements

---

I would like to express my sincere gratitude to a number of people who have supported me in my work and contributed to this dissertation.

First, I would like to express my sincere thanks to my supervisor Vivian Vimarlund who has guided me through these years of doctoral education. Thank you for introducing me to the exciting world of informatics. Thank you for all your support.

Thanks to my co-supervisor Toomas Timpka for all constructive comments and opinions, and for his enthusiasm and enormous knowledge within health informatics.

I would like to thank Anna Möberg, Rahman Mokhtari, Uppugunduri Srinivas, Mikael Svensson, co-writers of my papers, for all their good advices in developing the papers.

I am very thankful to Rahman Mokhtari again for preparing the opportunities to perform the study with integrated electronic prescribing system and introducing me the Östergötland county council to perform my study about computerized provider order entry system.

Thanks to Professor Nahid Shahmehri, who has been such a warm and gentle person! Thanks for always encouraging me to go forward. My sincere gratitude goes to Professor Mariam Kamkar for being supportive during my PhD studies.

I am so grateful to Naser Sheikhi who assisted me for statistical analysis. I know that he was very busy on that time, but he allocated his valuable time to help me to analyze my data.

My sincere gratitude goes to my scholarship sponsor, Urmia University of Medical Sciences (UMSU), Iranian Ministry of Health and Medical Education (MOHME).

My deepest gratitude goes to all colleagues in UMSU as well as MOHME for being so supportive and helpful during my PhD studies.

I truly appreciate my Licentiate opponents Nosrat Shahsavari and Göran Petersson for all their invaluable comments through the Licentiate thesis defense.

My sincere appreciation goes to Lillemor Wallgren for being supportive throughout my studies and my Licentiate thesis and PhD dissertation preparation.

I would like to express my thanks to IDA administrative staff, especially Lise-Lott Andersson, for being supportive throughout my Licentiate thesis and PhD dissertation preparation. I would like to thank my past and current colleagues at IDA and HCS division for their support.

I am so grateful to Elmira Rahbar who translated the employed questionnaires in this thesis into Swedish language.

I appreciate Agneta Nordenberg for all her kindness and assistance to perform one of my studies in the Östergötland county council.

I would like to express my appreciation to Ali Ardi for the thesis cover design.

I would like to express my appreciation to Eva Elfinger (ISM administrator) for kindly solving all administrative issues particularly at the beginning of my PhD studies at IDA.

I would like to express my thanks to the following friends, Amir Eghbali, Behzad Mesgarzadeh, Shanai Ardi, Amir Reza Razavi, Davood Shahsavani, Jalal Maleki, Imad Abugessaisa, Soheil Samii, Mohamed Abu Baker and others. I appreciate the time we spent together.

I would like to extend my appreciation by naming those colleagues that I did not mention them in the previous lines: Sture Hägglund, Henrik Eriksson, Arne Jönsson, Simin Nadjm Tehrani, Kip Smith, Harold "Bud" Lawson, Johan Åberg, Gudrun Wicander, Anne Moe, Inger Emanuelsson, Lisbeth Linge, Magnus Bång, Anders Larsson, Magnus Ingmarsson, Ola Leifler, Rolf Nilsson, and Göran Sedvall.

Thanks to my dear family for being so supportive and understanding. I thank my parents for always encouraging me to study. I am indebted to you for your love and support throughout my life. Thanks to my parents-in-law for being supportive and kind to me.

I sincerely appreciate my cute and lovely son Kiarash for making our life full of happiness.

Last but not least, my deepest gratitude goes to my lovely wife, Setareh, for always being with me and for constant encouragement. Thank you Setareh for being such a wonderful and loving wife, always listening and supporting me. Without you the completion of this thesis would have never been possible.

Bahlol Rahimi  
9 October 2009  
Linköping-Sweden



# Contents

---

|                                                                                                                                        |            |
|----------------------------------------------------------------------------------------------------------------------------------------|------------|
| <b>ABSTRACT</b> .....                                                                                                                  | <b>III</b> |
| <b>LIST OF PUBLICATIONS</b> .....                                                                                                      | <b>V</b>   |
| <b>ACKNOWLEDGEMENTS</b> .....                                                                                                          | <b>VII</b> |
| <b>INTRODUCTION</b> .....                                                                                                              | <b>1</b>   |
| 1    MOTIVATION .....                                                                                                                  | 1          |
| 1.1 <i>On implementation of HIS</i> .....                                                                                              | 2          |
| 1.2 <i>Evaluation of HIS</i> .....                                                                                                     | 3          |
| 2    AIM.....                                                                                                                          | 4          |
| P1. <i>Methodological approaches employed to capture the effects of HISs’<br/>implementation and use</i> .....                         | 5          |
| P2. <i>Challenges and problems involved with the implementation of integrated<br/>computerized patient record systems (ICPR)</i> ..... | 5          |
| P3. <i>Key factors which influence the implementation of HISs</i> .....                                                                | 6          |
| P4. <i>Impact of integrated electronic prescribing systems on work performance<br/>and patient safety</i> .....                        | 6          |
| P5. <i>Arisen issues as a consequence of the introduction and use of an integrated<br/>electronic prescribing system</i> .....         | 7          |
| P6. <i>Adoption of a computerized provider order entry system</i> .....                                                                | 7          |
| 3 <b>THESIS CONTRIBUTION</b> .....                                                                                                     | 8          |

|                           |                                                     |           |
|---------------------------|-----------------------------------------------------|-----------|
| 4                         | METHODS .....                                       | 8         |
| 4.1                       | <i>Context of the studies</i> .....                 | 9         |
| 4.2                       | <i>Methods used in the papers</i> .....             | 11        |
| 4.1.1                     | <i>Paper I: A literature review</i> .....           | 11        |
| 4.1.2                     | <i>Paper II: An explorative case study</i> .....    | 12        |
| 4.1.3                     | <i>Paper III: A qualitative Meta-Analysis</i> ..... | 13        |
| 4.1.4                     | <i>Paper IV and V: A survey research</i> .....      | 14        |
| 4.1.5                     | <i>Paper VI: A survey research</i> .....            | 16        |
| 5                         | RESULTS OF PAPERS .....                             | 19        |
| 1.1                       | <i>Result of Paper I</i> .....                      | 19        |
| 1.2                       | <i>Result of Paper II</i> .....                     | 21        |
| 1.3                       | <i>Result of Paper III</i> .....                    | 24        |
| 1.4                       | <i>Result of Paper IV</i> .....                     | 28        |
| 1.5                       | <i>Results of Paper V</i> .....                     | 32        |
| 1.6                       | <i>Result of Paper VI</i> .....                     | 41        |
| 6                         | DISCUSSION .....                                    | 46        |
| 7                         | CONCLUSION REMARKS AND FUTURE WORK .....            | 50        |
| 8                         | REFERENCES .....                                    | 55        |
| <b>PAPER I - VI .....</b> |                                                     | <b>63</b> |

## **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)<sup>1</sup> 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 Meijden 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.

---

<sup>1</sup> 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]

## 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

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

*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.

*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.

### **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.

| Paper | Aim                                                                                           | Method            | Data collection method                                      |
|-------|-----------------------------------------------------------------------------------------------|-------------------|-------------------------------------------------------------|
| I     | The methodological approaches employed to capture the effects of HISs' implementation and use | Literature review | Published articles from 2003 to 2005                        |
| II    | The challenges and problems concerning implementation of a ICPRs                              | Case study        | Interviews with 40 staff and document analyses              |
| III   | The key factors which influence the implementation of HISs                                    | Meta-analysis     | Published articles from 2003 to 2007                        |
| IV    | Introduction of an IEPS with regard to its impact on efficiency and patient safety            | Survey            | Questionnaire completed by 63 pharmacists                   |
| V     | Arisen issues as a consequence of the introduction and use of an IEPS                         | Survey            | Questionnaire completed by 63 pharmacists                   |
| VI    | Adoption of a computerized provider order entry system                                        | Survey            | 2 Questionnaires completed by 134 nurses and 176 physicians |

**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).

|            | Östergötland county | Linköping |
|------------|---------------------|-----------|
| Population | 423 169             | 141 863   |
| Hospital   | 3                   | 1         |
| PHC        | 42                  | 13        |

**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

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

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

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 reformulated 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 inevitable 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”*

Rahimi, B., and Vimarlund, V., Methods to evaluate health information systems in healthcare settings: A literature review. *J. Med. Syst.* 31:397–432, 2007.

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).

| <b>Type of HIS</b>   | <b>Evaluation studies' direction</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| CPR studies          | <ul style="list-style-type: none"> <li>-The system usefulness regarding the quality of care</li> <li>- User-related issues such as user acceptance and satisfaction and attitudes towards new systems</li> <li>- The financial effects, usually limited to the identification of the costs of system implementation</li> <li>- 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</li> </ul> |
| Telemedicine studies | <ul style="list-style-type: none"> <li>-The economic effects of system implementation</li> <li>- Effectiveness in the telemedicine area</li> <li>- Studies regarding user attitudes and perspectives, user satisfaction</li> <li>- The usefulness of the system such as time of service delivery, usability, feasibility</li> </ul>                                                                                                                                                                                            |
| DSS studies          | <ul style="list-style-type: none"> <li>-The usability of systems</li> <li>-The effectiveness of the system for patients</li> <li>- Financial impacts of introducing the new system</li> <li>- Measures of user satisfaction and attitudes towards the system</li> </ul>                                                                                                                                                                                                                                                        |

**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.

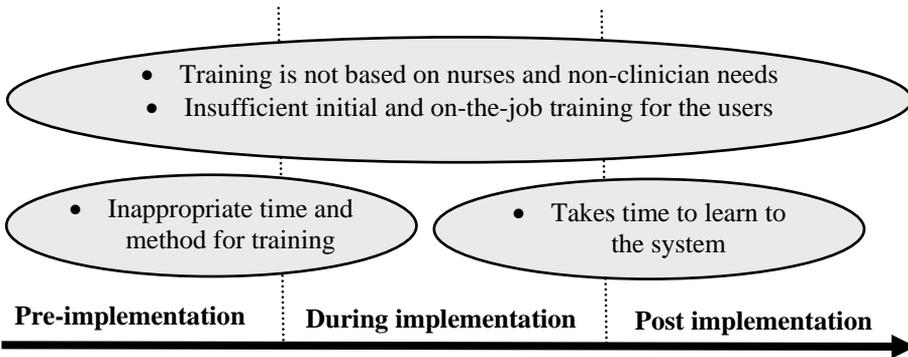
The findings also show that economic and organizational aspects dominate evaluation studies in this area. However, the results focus mostly on positive outputs such as user satisfaction, financial benefits and improved organizational work.

## **1.2 Result of Paper II**

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

Rahimi, B., Moberg, A., Timpka, T. and Vimarlund, V. Implementing an integrated computerized patient record system: Toward for an evidence-based information system implementation practice in healthcare, *AMIA Annu. Symp. Proc. November 8-12, 2008*.

We categorized our finding into three groups those are: medical informatics skills, human–computer interaction, and attitudes and expectation.



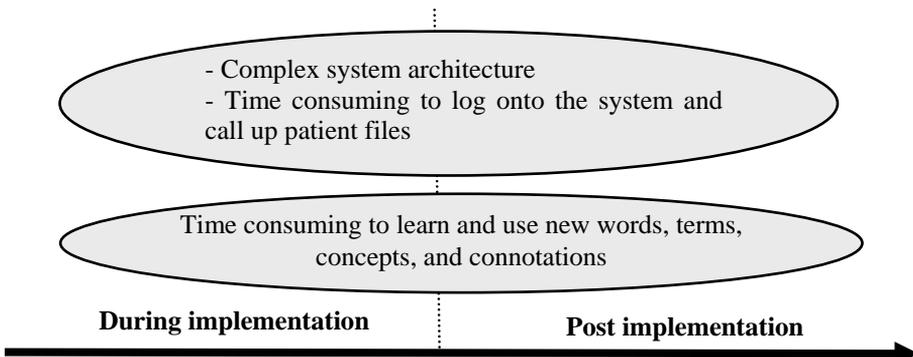
**Figure 1:** Display of the first-order analysis results related to medical informatics knowledge and skills

**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.

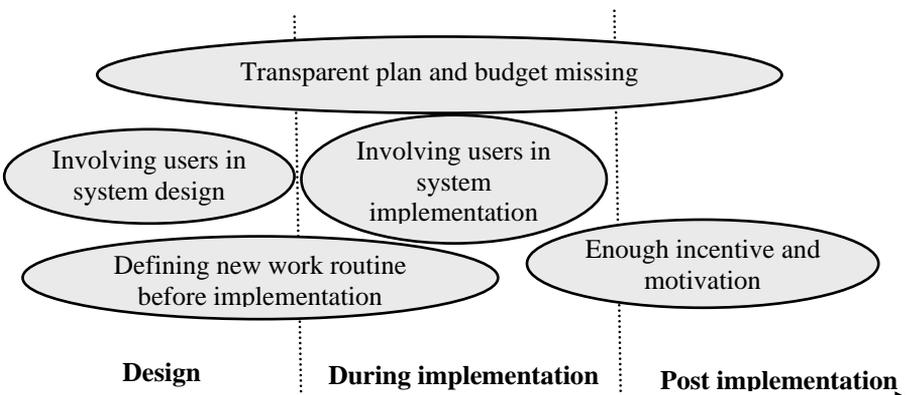
Once the system was implemented, ongoing support was reported to be crucial for the success of the newly implemented system. They asked for the option of further training in order to overcome day-to-day problems.



*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*

***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”*

Rahimi, B., Vimarlund, V., and Timpka, T. Health information system implementation: A qualitative meta-analysis. J Med Syst. DOI 10.1007/s10916-008-9198-9

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.

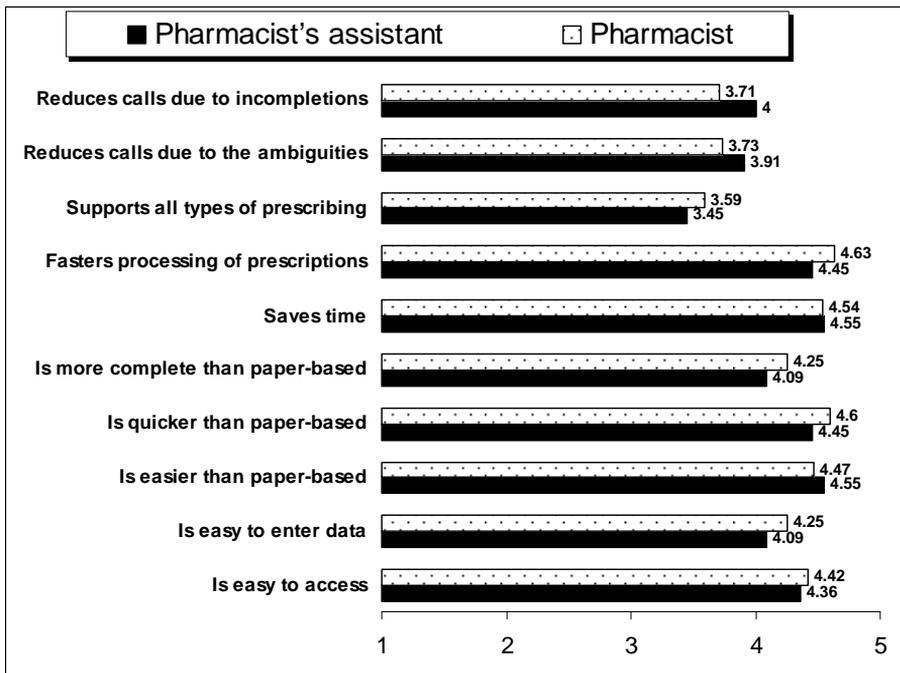
#### 1.4 Result of Paper IV

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

Rahimi, B., Vimarlund, V., Mokhtari, R., and Timpka, T. Integrated electronic prescribing systems: pharmacists’ perceptions of impact on work performance and patient safety. *The 9th WSEAS, AIC’09 Proc*, August 20-22, 2009, Moscow, Russia.

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).



**Figure 4:** Perceived usefulness and ease of use of electronic prescribing on pharmacists' work process (scale 1 = low contribution to 5 = high contribution).

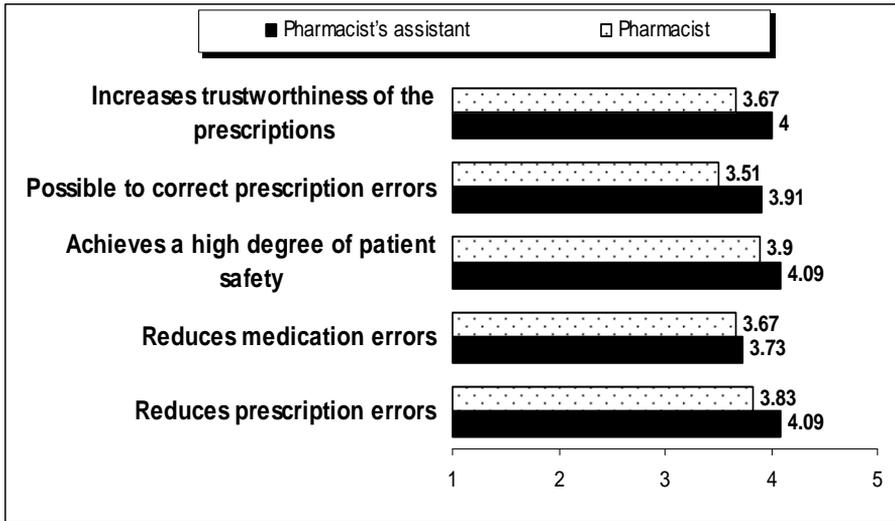
The capability of the system to support all types of prescribing was perceived as a less important contribution to enhance job performance: mean score 3.59 (95% CI, 3.27–3.91) for pharmacists and 3.45 (95% CI, 2.76–4.15) for pharmacist's assistants.

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, 3.422–3.80) 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).

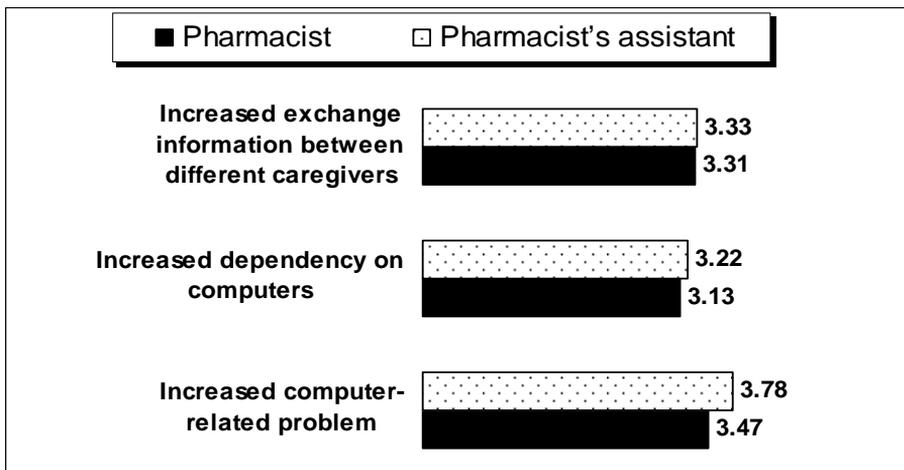
28.8% of pharmacists and 18.2% of pharmacist’s assistants reported that the introduction of the IEPS had proceeded very well in their work setting, while the remaining respondents reported that the system introduction had gone well. None of the respondents indicated that the introduction had progressed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

| Safety issue          | Profession             | Increase | No change | Decrease |
|-----------------------|------------------------|----------|-----------|----------|
| Confusion of drugs    | Pharmacist             | 9.6%     | 26.9%     | 63.5%    |
|                       | Pharmacist's assistant | 0.0%     | 9.1%      | 90.9%    |
| Confusion of patients | Pharmacist             | 15.4%    | 23.1%     | 61.5%    |
|                       | Pharmacist's assistant | 0.0%     | 9.1%      | 90.9%    |
| Forgery risk          | Pharmacist             | 3.8%     | 13.5%     | 82.7%    |
|                       | Pharmacist's assistant | 0.0%     | 9.1%      | 90.9%    |

*Table 4. Perception of impact of the IEPS on selected safety issues.*

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).



*Figure 6: Perception of development possibilities for the IEPS (scale 1 = low need to 5 = high need).*

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.

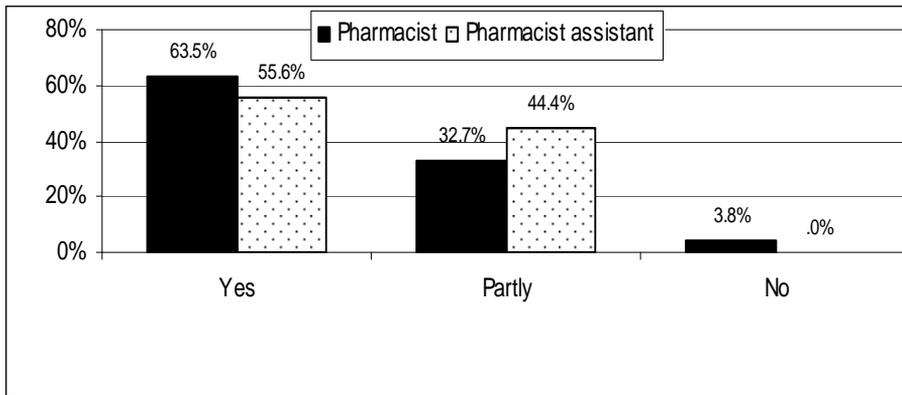
### 1.5 Results of Paper V

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

Rahimi, B., Vimarlund, V. Introduction of an integrated electronic prescribing system: The pharmacies staff dimensions. ISHIMR 2009 Conference. October 14-16, 2009. (In press)

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.

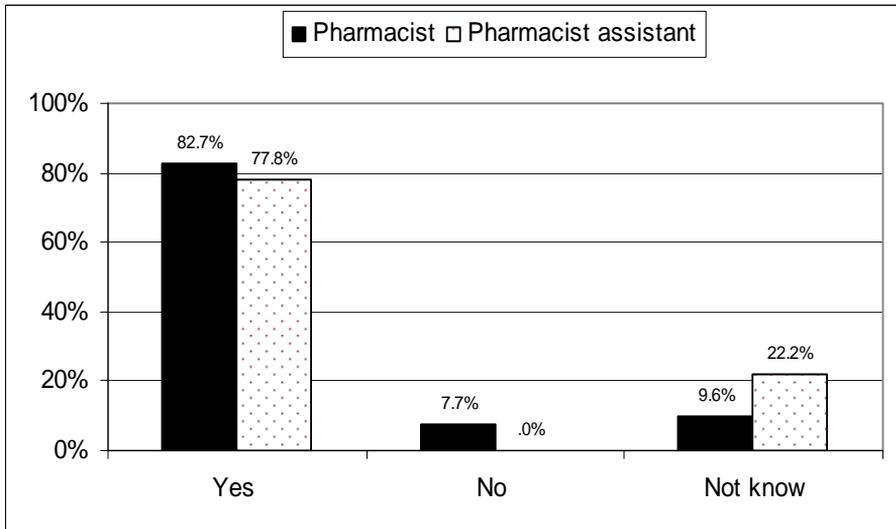
About two-thirds of the pharmacists (63.5%) and more than one-half of the pharmacist assistants (55.6%) reported that they trust the IEPS (Figure 7). However, 3.8% of the pharmacists did not trust the IEPS.



**Figure 7:** Distribution of Respondents’ Answers about Trust in IEPS.

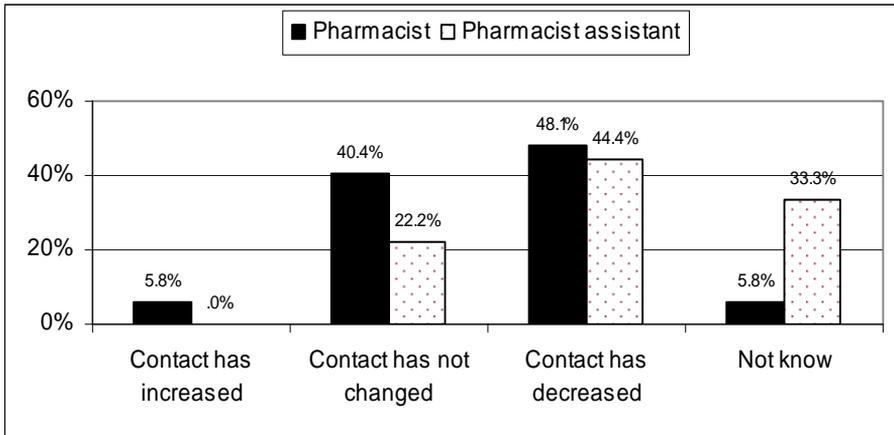
The respondents’ answers to questions related to safety issues showed that 82.7% of the pharmacists and 77.8% of pharmacist assistants agreed that e-prescriptions are safer than paper ones. Only 7.7% of the

pharmacists did not agree that e-prescriptions are safer than paper ones (Figure 8).



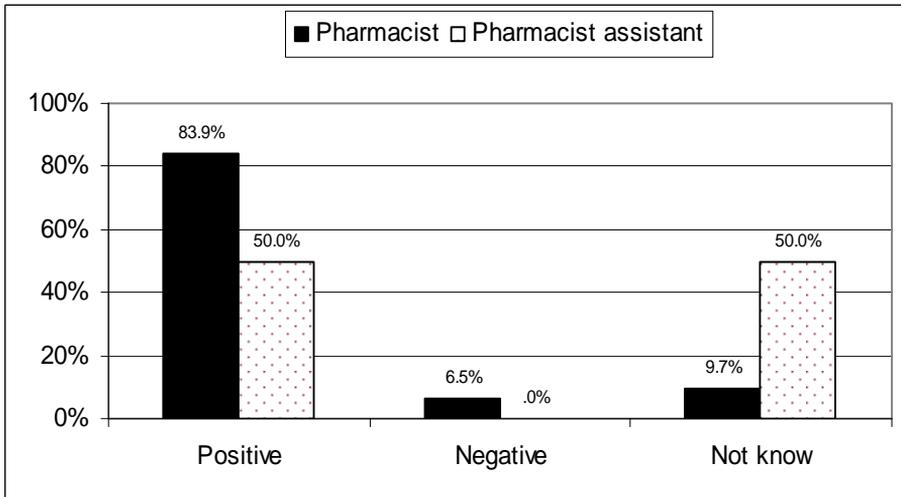
**Figure 8:** Distribution of Respondents' Answers about Whether E-Prescriptions Are Safer Than Paper Prescriptions.

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.



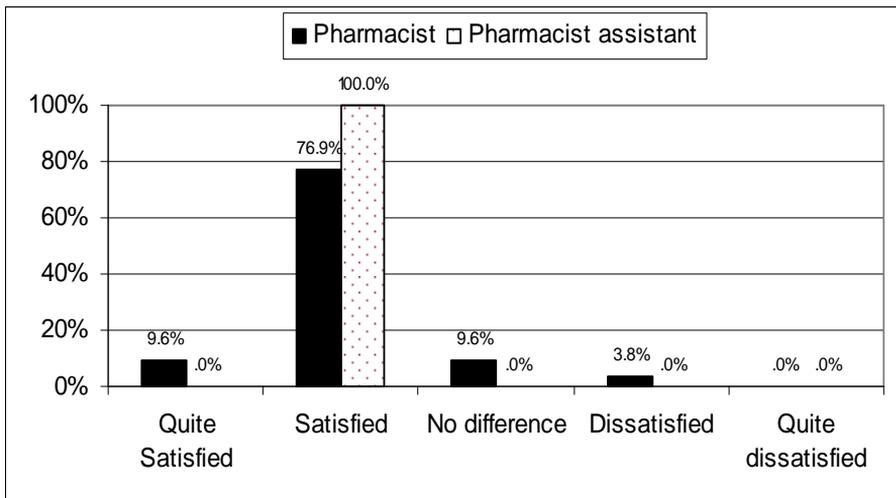
**Figure 9:** Distribution of Respondents' Answers about How Contact Between Pharmacists and Prescribers Has Changed.

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).



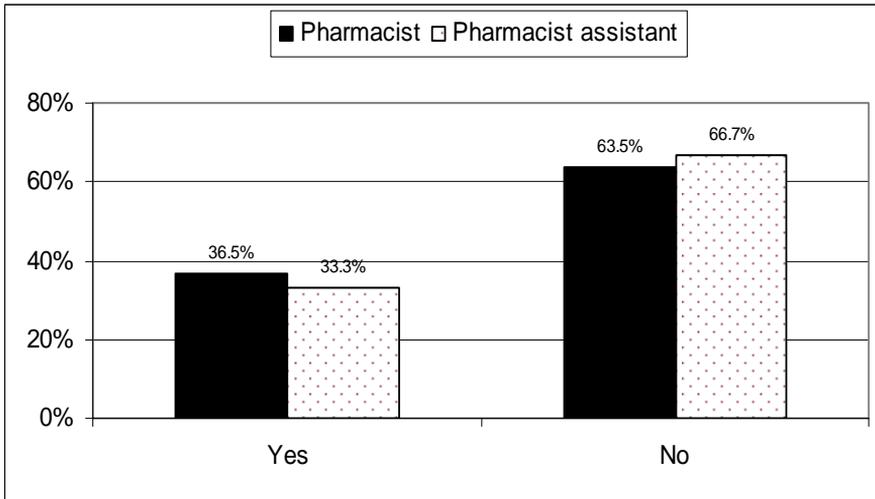
**Figure 10:** Distribution of Respondents' Answers about How the IEPS Has Affected the Quality of Contact with Prescribers, if the IEPS Changed the Level of Contact.

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).



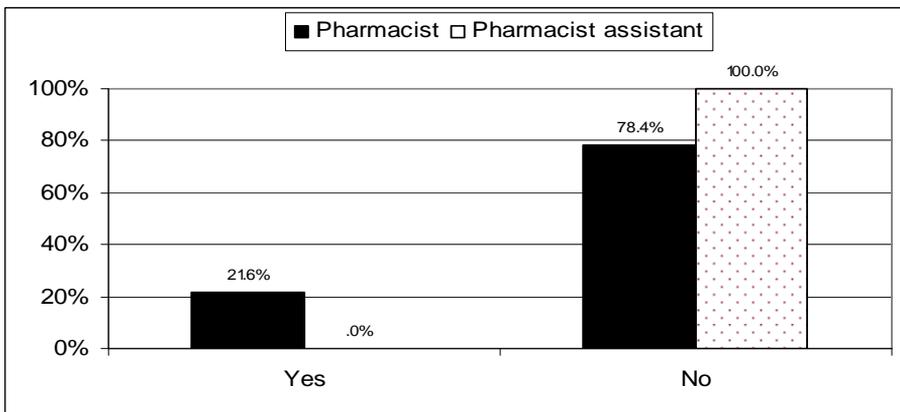
**Figure 7:** Distribution of Respondents' Answers about the Level of Satisfaction for Pharmacy Customers since the Introduction of the IEPS.

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).



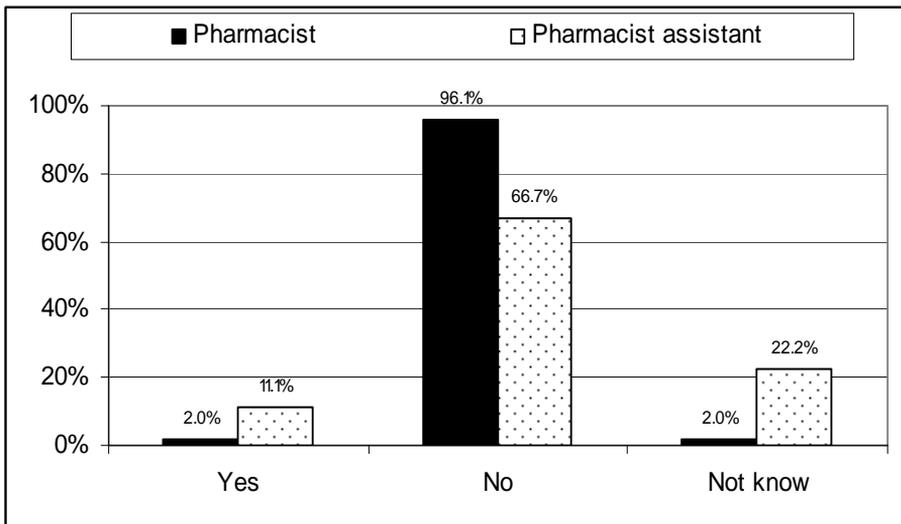
**Figure 12:** Distribution of Respondents’ Answers About Whether Using the IEPS in the Last 10 Days Prevented Medication Errors Before the Error Reached the Patient.

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 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.

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.

| Pharmacists                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Pharmacist assistants                                                                                                                                                                                                                                     |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> <li>• Legibility was increased</li> <li>• Forgery risk has decreased</li> <li>• Improved patient safety</li> <li>• Drug overusing has decreased</li> <li>• Faster expedition time rather than previous one</li> <li>• Decreased telephone prescription</li> <li>• Customers cannot take double prescription</li> <li>• Time saving for patients</li> <li>• The risk of confusing of prescribing between drugs has decreased</li> </ul> | <ul style="list-style-type: none"> <li>• Legibility was increased</li> <li>• Forgery risk has decreased</li> <li>• Increases patient safety</li> <li>• Drug overusing has decreased</li> <li>• Faster expedition time rather than previous one</li> </ul> |

**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.

| Pharmacists                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Pharmacist assistants                                                                                                                                                                                                                                                                            |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"> <li>• Computers disconnect sometimes</li> <li>• It takes time for pharmacists to correct the wrong prescription</li> <li>• It is difficult to change medicine package size</li> <li>• The doctor cannot cancel the order he has sent</li> <li>• Sometimes the doctor sends many similar prescriptions</li> <li>• Mistakes such as entering wrong drug on computer due to the similarity of drug names or the code occurs</li> </ul> | <ul style="list-style-type: none"> <li>• Computers disconnect sometimes</li> <li>• It takes time for pharmacists to correct the wrong prescription</li> <li>• Takes time to enter the data for paper–prescription one in the system</li> <li>• The system sometimes works very slowly</li> </ul> |

**Table 6:** Free text voices from end users about the new arisen problems after IEPS

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.

|                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|-----------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Pharmacists           | <ul style="list-style-type: none"> <li>• Giving prescribers the opportunity to cancel or change their ordered prescriptions in case of double or wrong prescriptions.</li> <li>• Giving patients the opportunity to check the status of their prescription(s) on the Web.</li> <li>• Periodically updating the pharmacies' computers and the IEPS.</li> <li>• Giving pharmacists the opportunity to take a short training course to learn how the physician order entry system works.</li> <li>• 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.</li> <li>• Providing sufficient user training to prevent mistakes and decrease calls from pharmacies to the prescribers.</li> </ul> |
| Pharmacist assistants | <ul style="list-style-type: none"> <li>• 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.</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |

**Table 7:** Free text voices from end users about the general suggestions on how to improve the IEPS

## 1.6 Result of Paper VI

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

Rahimi, B., Vimarlund, V., Timpka, T., Svensson, M., Srinivas, U. Adoption of computerized provider order entry systems: An organization-wide study based on diffusion of innovations theory. Submitted to BMC medical Informatics and Decision Making journal.

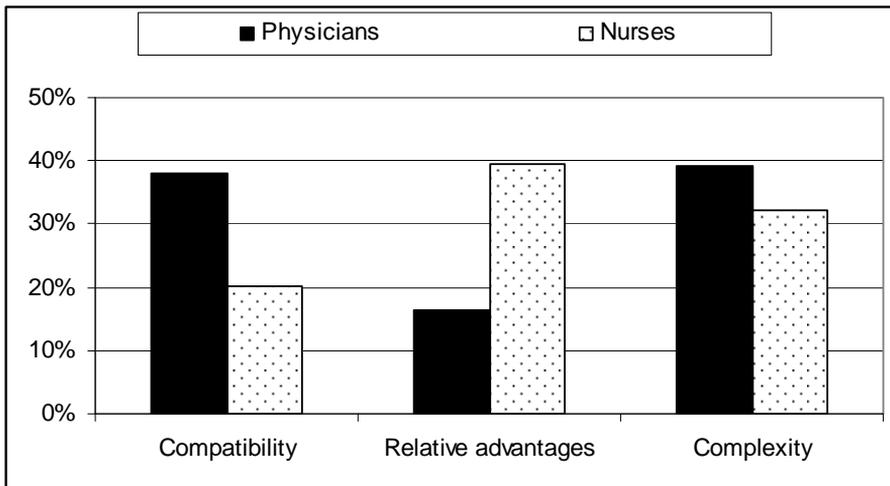
The characteristics of respondents participating in this study can be seen in Table 8.

| Characteristic                          | Physicians (n=176) | Nurses (n=134) |
|-----------------------------------------|--------------------|----------------|
| <b>Sex</b>                              |                    |                |
| Male                                    | 98 (55.7%)         | 13 (9.7 %)     |
| Female                                  | 78 (44.3%)         | 121 (90.3%)    |
| <b>Age groups</b>                       |                    |                |
| 20-29 y                                 | 9 (5.1%)           | 3 (2.2%)       |
| 30-39 y                                 | 40 (22.9%)         | 34 (25.4%)     |
| 40-49 y                                 | 49 (28.%)          | 42 (31.3%)     |
| 50-59 y                                 | 53 (30.3%)         | 44 (32.8%)     |
| > 60 y                                  | 24 (13.7%)         | 11 (8.2%)      |
| <b>Workplace</b>                        |                    |                |
| Primary health care center              | 43 (24.4%)         | 9 (6.7%)       |
| Hospital                                | 133 (75.6 %)       | 117 (87.3%)    |
| Home care                               | 0                  | 8 (6.0%)       |
| <b>County district</b>                  |                    |                |
| Central                                 | 102 (58.0%)        | 86 (64.2%)     |
| East                                    | 36 (20.5%)         | 26 (19.4%)     |
| West                                    | 38 (21.5 %)        | 22 (16.4%)     |
| <b>Time of CPOE system use</b>          |                    |                |
| < 6 months                              | 47 (26.7%)         | 43 (32.1%)     |
| 6-12 months                             | 34 (19.3%)         | 47 (35.1%)     |
| > 1 year                                | 95 (54.0%)         | 44 (32.8%)     |
| <b>Number of orders in a normal day</b> |                    |                |
| > 20                                    | 45 (25.6%)         | 51 (38.1%)     |
| 10-20                                   | 76 (43.2%)         | 27 (20.1%)     |
| < 10                                    | 55 (31.2%)         | 56 (41.8%)     |

*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.

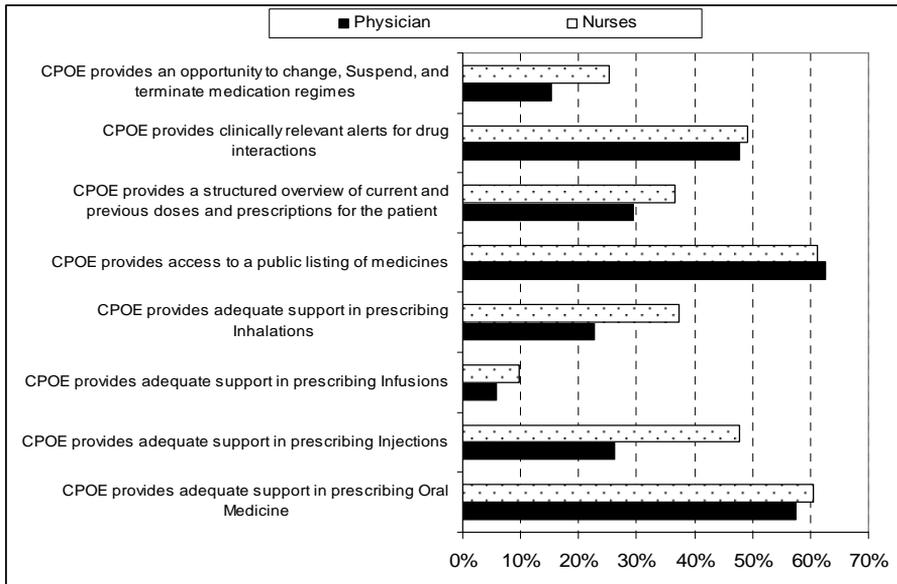
When comparing the composed index for the three attributions of the diffusion of innovation theory (Figure 11), we found that the relative advantages of the CPOE system was 39.6% among nurses and 16.5% among physicians. However, physicians’ agreements with the compatibility of the CPOE and with its complexity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



**Figure 11:** Overall level of CPOE compatibility, advantages and complexity

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).

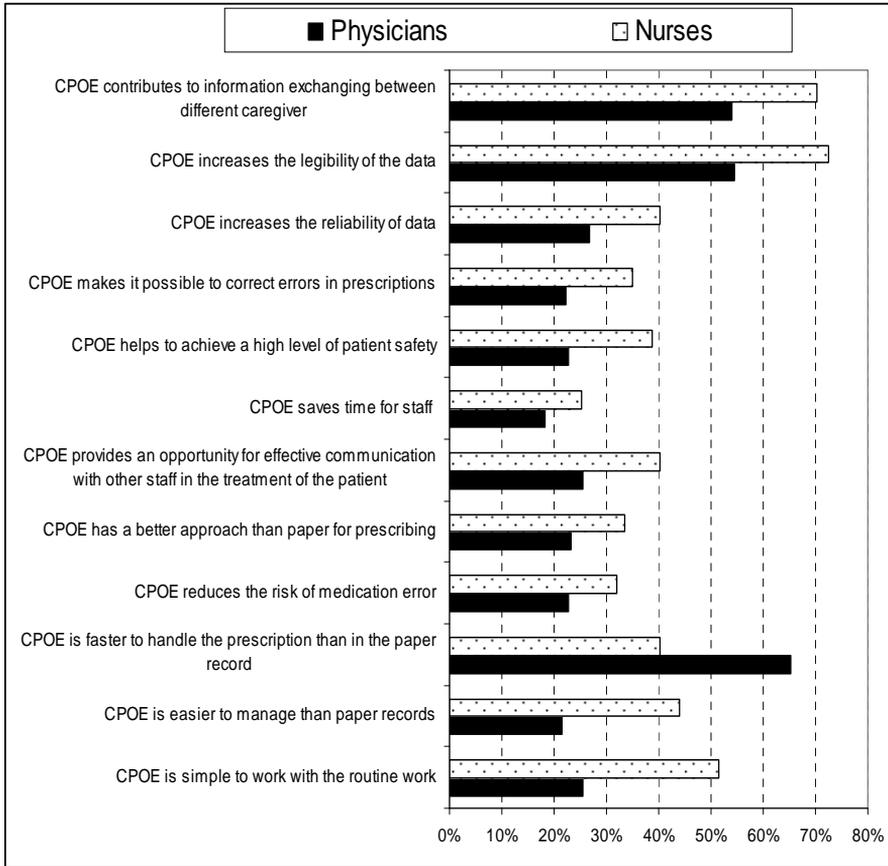


**Figure 12:** Distribution of the respondents' agreement about how much the CPOE system support the supposed functions

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).

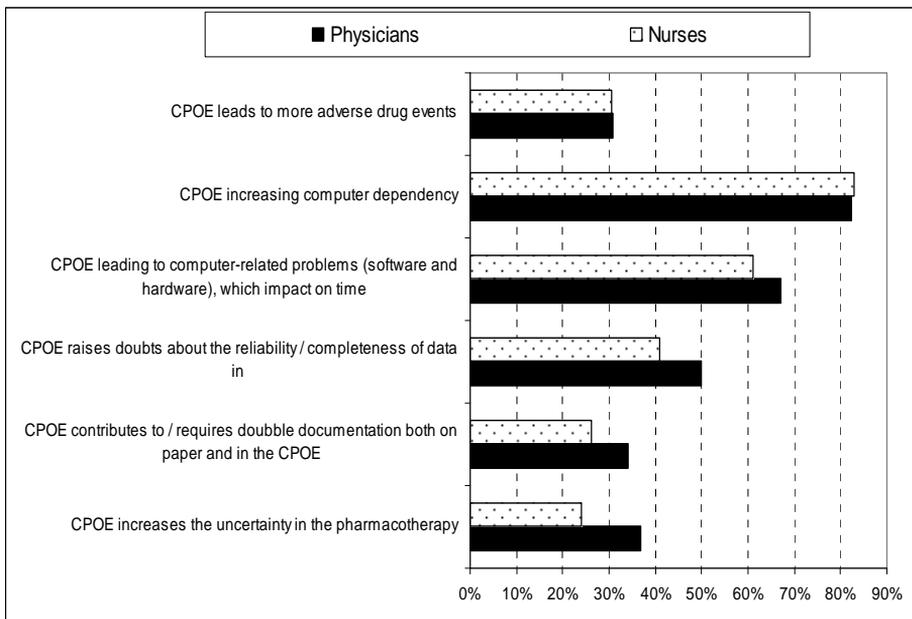


**Figure 13:** Distribution of respondents’ agreement about relative advantages of the CPOE system

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

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

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

attention towards individual, managerial, organizational, and social issues.

## 8 References

- (1) Shortliffe EH, Blois MS. The Computer Meets Medicine and Biology: Emergence of a Discipline. In: "Edward H. Shortliffe", "James J. Cimino", editor. *Biomedical Informatics: Computer Applications in Health Care and Biomedicine*. 3rd ed. New York: Springer; 2006.
- (2) Vimarlund V, Olve NG, Scandurra I, Koch S. Organizational effects of information and communication technology (ICT) in elderly homecare: a case study. *Health Informatics J*. 2008 Sep;14(3):195-210.
- (3) Rose AF, Schnipper JL, Park ER, Poon EG, Li Q, Middleton B. Using qualitative studies to improve the usability of an EMR. *J.Biomed.Inform*. 2005 Feb;38(1):51-60.
- (4) Winkelman WJ, Leonard KJ. Overcoming structural constraints to patient utilization of electronic medical records: a critical review and proposal for an evaluation framework. *J.Am.Med.Inform.Assoc*. 2004 Mar-Apr;11(2):151-161.
- (5) Chamorro T. Computer-based patient record systems.. *Semin Oncol Nurs* 2001;17(1):24-33.
- (6) Ammenwerth E, Brender J, Nykanen P, Prokosch HU, Rigby M, Talmon J, et al. Visions and strategies to improve evaluation of health information systems. Reflections and lessons based on the HIS-EVAL workshop in Innsbruck. *Int.J.Med.Inform*. 2004 Jun 30;73(6):479-491.
- (7) Forslund D. Improving Swedish healthcare by using eHealth solutions – strategic decisions towards SNOMED CT. 2009; , 2009.
- (8) Jha AK, Doolan D, Grandt D, Scott T, Bates DW. The use of health information technology in seven nations. *Int.J.Med.Inform*. 2008 Dec;77(12):848-854.
- (9) Vimarlund V, Olve N-. Economic analyses for ICT in elderly healthcare: Questions and challenges. *Health Informatics Journal* 2005;11(4):309-321.
- (10) Olve NG, Vimarlund V. Locating ICT's benefits in elderly care. *Med.Inform.Internet Med*. 2005 Dec;30(4):297-308.
- (11) Timpka T, Bång M, Delbanco T, Walker J. Information infrastructure for inter-organizational mental health services: An actor network theory analysis of psychiatric rehabilitation. *J.Biomed.Inform.*; *J.Biomed.Informatics* 2007;40(4):429-437.

- (12) Friedman CP, Wyatt JC. Evaluation methods in biomedical informatics. 2nd ed. New York: Springer; 2006.
- (13) Anderson JG, Aydin CE, Jay SJ. Evaluating health care information systems : methods and applications. Thousand Oaks, Calif.: Sage; 1994.
- (14) Harrison MI, Koppel R, Bar-Lev S. Unintended consequences of information technologies in health care--an interactive sociotechnical analysis. *J.Am.Med.Inform.Assoc.* 2007 Sep-Oct;14(5):542-549.
- (15) Koch S. Meeting the challenges--the role of medical informatics in an ageing society. *Stud.Health Technol.Inform.* 2006;124:25-31.
- (16) Lehmann HP. Aspects of electronic health record systems. 2nd ed. New York: Springer; 2006.
- (17) Anderson JG, Aydin CE, NetLibrary I. Evaluating the organizational impact of healthcare information systems. 2005:344.
- (18) Chismar WG, Thomas SM. The economics of integrated electronic medical record systems. *Stud.Health Technol.Inform.* 2004;107(Pt 1):592-596.
- (19) Georgiou A, Ampt A, Creswick N, Westbrook JI, Braithwaite J. Computerized Provider Order Entry--what are health professionals concerned about? A qualitative study in an Australian hospital. *Int.J.Med.Inform.* 2009 Jan;78(1):60-70.
- (20) Ash JS, Sittig DF, Dykstra R, Campbell E, Guappone K. The unintended consequences of computerized provider order entry: findings from a mixed methods exploration. *Int.J.Med.Inform.* 2009 Apr;78 Suppl 1:S69-76.
- (21) Berg M. Implementing information systems in health care organizations: myths and challenges. *Int.J.Med.Inform.* 2001 Dec;64(2-3):143-156.
- (22) Littlejohns P, Wyatt JC, Garvican L. Evaluating computerised health information systems: hard lessons still to be learnt. *BMJ* 2003 Apr 19;326(7394):860-863.
- (23) Garde S, Hullin CM, Chen R, Schuler T, Granz J, Knaup P, et al. Towards sustainability of health information systems: how can we define, measure and achieve it? *Stud.Health Technol.Inform.* 2007;129(Pt 2):1179-1183.
- (24) Heeks R. Health information systems: failure, success and improvisation. *Int.J.Med.Inform.* 2006 Feb;75(2):125-137.

- 
- (25) Berg M. The search for synergy: interrelating medical work and patient care information systems. *Methods Inf.Med.* 2003;42(4):337-344.
- (26) Rotich JK, Hannan TJ, Smith FE, Bii J, Odero WW, Vu N, et al. Installing and implementing a computer-based patient record system in sub-Saharan Africa: the Mosoriot Medical Record System. *J.Am.Med.Inform.Assoc.* 2003 Jul-Aug;10(4):295-303.
- (27) Arias-Vimarlund V, Ljunggren M, Timpka T. Implementation of computer-based patient records in primary care: the societal health economic effects. *Proc.AMIA.Annu.Fall.Symp.* 1996:503-507.
- (28) Ash JS, Sittig DF, Dykstra RH, Guappone K, Carpenter JD, Seshadri V. Categorizing the unintended sociotechnical consequences of computerized provider order entry. *Int.J.Med.Inform.* 2007 Jun;76 Suppl 1:S21-7.
- (29) Fullerton C, Aponte P, Hopkins R, Bragg D, Ballard DJ. Lessons learned from pilot site implementation of an ambulatory electronic health record. *Proc.(Bayl Univ.Med.Cent)* 2006 Oct;19(4):303-310.
- (30) Van Der Meijden MJ, Tange HJ, Troost J, Hasman A. Determinants of success of inpatient clinical information systems: a literature review. *J.Am.Med.Inform.Assoc.* 2003 May-Jun;10(3):235-243.
- (31) Kushniruk AW, Borycki E. Human, social, and organizational aspects of health information systems. Hershey: Medical Information Science Reference; 2008.
- (32) Doebbeling BN, Pekny J. The role of systems factors in implementing health information technology. *J.Gen.Intern.Med.* 2008 Apr;23(4):500-501.
- (33) Pagliari C. Design and evaluation in eHealth: challenges and implications for an interdisciplinary field. *J.Med.Internet Res.* 2007 May 27;9(2):e15.
- (34) Westbrook JI, Braithwaite J, Iedema R, Coiera EW. Evaluating the impact of information communication technologies on complex organizational systems: a multi-disciplinary, multi-method framework. *Stud.Health Technol.Inform.* 2004;107(Pt 2):1323-1327.
- (35) Ammenwerth E, de Keizer N. An inventory of evaluation studies of information technology in health care trends in evaluation research 1982-2002. *Methods Inf.Med.* 2005;44(1):44-56.
- (36) Yusof MM, Kuljis J, Papazafeiropoulou A, Stergioulas LK. An evaluation framework for Health Information Systems: human, organization and technology-fit factors (HOT-fit). *Int.J.Med.Inform.* 2008 Jun;77(6):386-398.

- (37) Yusof MM, Stergioulas L, Zugic J. Health information systems adoption: findings from a systematic review. *Stud.Health Technol.Inform.* 2007;129(Pt 1):262-266.
- (38) Kaplan B, Shaw NT. Future directions in evaluation research: people, organizational, and social issues. *Methods Inf.Med.* 2004;43(3):215-231.
- (39) Poon EG, Blumenthal D, Jaggi T, Honour MM, Bates DW, Kaushal R. Overcoming barriers to adopting and implementing computerized physician order entry systems in U.S. hospitals. *Health.Aff.(Millwood)* 2004 Jul-Aug;23(4):184-190.
- (40) Galliers RD, Leidner DE. Strategic information management : challenges and strategies in managing information systems. 3rd ed. Oxford: Butterworth-Heinemann; 2003.
- (41) Ammenwerth E, de Keizer N. A viewpoint on evidence-based health informatics, based on a pilot survey on evaluation studies in health care informatics. *J.Am.Med.Inform.Assoc.* 2007 May-Jun;14(3):368-371.
- (42) Ammenwerth E. Health technology assessment. Findings from the Section on Assessing Information Technologies for Health. *Yearb.Med.Inform.* 2006:16-19.
- (43) Kaplan B. Culture counts: how institutional values affect computer use. *MD Comput.* 2000 Jan-Feb;17(1):23-26.
- (44) Ammenwerth E, Schnell-Inderst P, Machan C, Siebert U. The Effect of Electronic Prescribing on Medication Errors and Adverse Drug Events: A Systematic Review. *J.Am.Med.Inform.Assoc.* 2008 September-October;15(5):585-600.
- (45) Miller RA, Gardner RM, Johnson KB, Hripcsak G. Clinical decision support and electronic prescribing systems: a time for responsible thought and action. *J.Am.Med.Inform.Assoc.* 2005 Jul-Aug;12(4):403-409.
- (46) Kohn LT, Corrigan JM, Donaldson MS editors. To err is human: building a safer health system. Washington DC: Institute of Medicine report. National Academies Press; 1999.
- (47) Eslami S, de Keizer NF, Abu-Hanna A. The impact of computerized physician medication order entry in hospitalized patients--a systematic review. *Int.J.Med.Inform.* 2008 Jun;77(6):365-376.
- (48) Campbell EM, Sittig DF, Guappone KP, Dykstra RH, Ash JS. Overdependence on technology: an unintended adverse consequence of computerized provider order entry. *AMIA.Annu.Symp.Proc.* 2007:94-98.

- 
- (49) School of Informatics. What is Informatics? 2009; Available at: [http://informatics.iupui.edu/overview/what\\_is\\_informatics.php](http://informatics.iupui.edu/overview/what_is_informatics.php). Accessed August 18, 2009.
- (50) Bloomrosen M. Building the Workforce for Health System Transformation. 2008; Available at: [http://www.amia.org/files/shared/Capitol\\_Hill\\_Steering\\_Committee\\_\\_04\\_17\\_08.pdf](http://www.amia.org/files/shared/Capitol_Hill_Steering_Committee__04_17_08.pdf). Accessed August 11, 2009.
- (51) The National High-Level Group for e-Health. Swedish Strategy for eHealth: Safe and accessible information in health and social care (Status report 2009). 2009; Available at: <http://www.regeringen.se/content/1/c6/12/48/02/a97569e9.pdf>, 2009.
- (52) Cambio Healthcare System. COSMIC Order Management - It couldn't be any simpler. 2009; Available at: [http://www.cambio.se/document/en-us/Clinical\\_Eng.pdf](http://www.cambio.se/document/en-us/Clinical_Eng.pdf). Accessed June 5, 2009.
- (53) Robert K. Yin. Case Study Research: Design and Methods. 4th ed.: Sage; 2008.
- (54) Patton MQ. Qualitative Research and Evaluation Methods. 3rd ed. California: Sage; 2002.
- (55) Yin RK. Case study research : design and methods. 4th ed. London: Sage; 2009.
- (56) Noblit GW, Hare RD. Meta-ethnography : synthesizing qualitative studies. Beverly Hills, Calif.: Sage Publications; 1987.
- (57) Atkins S, Lewin S, Smith H, Engel M, Fretheim A, Volmink J. Conducting a meta-ethnography of qualitative literature: lessons learnt. BMC Med.Res.Methodol. 2008 Apr 16;8:21.
- (58) McCormick J, Rodney P, Varcoe C. Reinterpretations across studies: an approach to meta-analysis. Qual.Health Res. 2003 Sep;13(7):933-944.
- (59) Finlayson KW, Dixon A. Qualitative meta-synthesis: a guide for the novice. Nurse.Res. 2008;15(2):59-71.
- (60) Flemming K. Synthesis of qualitative research and evidence-based nursing. Br.J.Nurs. 2007 May 24-Jun 13;16(10):616-620.
- (61) Reis S, Hermoni D, Van-Raalte R, Dahan R, Borkan JM. Aggregation of qualitative studies--From theory to practice: Patient priorities and family medicine/general practice evaluations. Patient Educ.Couns. 2007 Feb;65(2):214-222.

(62) Brender J. Handbook of evaluation methods for health informatics. Amsterdam: Elsevier Academic Press; 2006.

(63) Fishbein M, Ajzen I. Belief, attitude, intention and behavior : an introduction to theory and research. Reading, Mass.: Addison-Wesley; 1975.

(64) Wu J-, Shen W-, Lin L-, Greenes RA, Bates DW. Testing the technology acceptance model for evaluating healthcare professionals' intention to use an adverse event reporting system. *International Journal for Quality in Health Care* 2008;20(2):123-129.

(65) Schaper LK, Pervan GP. ICT and OTs: a model of information and communication technology acceptance and utilisation by occupational therapists. *Int.J.Med.Inform.* 2007 Jun;76 Suppl 1:S212-21.

(66) King WR, He J. A meta-analysis of the technology acceptance model. *Information and Management* 2006;43(6):740-755.

(67) Yarbrough AK, Smith TB. Technology acceptance among physicians: a new take on TAM. *Med.Care Res.Rev.* 2007 Dec;64(6):650-672.

(68) Rogers EM. Diffusion of innovations. 5th ed. New York: Free press; 2003.

(69) Ford EW, McAlearney AS, Phillips MT, Menachemi N, Rudolph B. Predicting computerized physician order entry system adoption in US hospitals: can the federal mandate be met? *Int.J.Med.Inform.* 2008 Aug;77(8):539-545.

(70) Berwick DM. Disseminating innovations in health care. *JAMA* 2003 Apr 16;289(15):1969-1975.

(71) Ash JS, Sittig DF, Poon EG, Guappone K, Campbell E, Dykstra RH. The extent and importance of unintended consequences related to computerized provider order entry. *J.Am.Med.Inform.Assoc.* 2007 Jul-Aug;14(4):415-423.

(72) Classen DC, Avery AJ, Bates DW. Evaluation and certification of computerized provider order entry systems. *J.Am.Med.Inform.Assoc.* 2007 Jan-Feb;14(1):48-55.

(73) Zhan C, Hicks RW, Blanchette CM, Keyes MA, Cousins DD. Potential benefits and problems with computerized prescriber order entry: analysis of a voluntary medication error-reporting database. *Am.J.Health.Syst.Pharm.* 2006 Feb 15;63(4):353-358.

- 
- (74) Pirnejad H, Niazkhani Z, van der Sijs H, Berg M, Bal RA. Evaluation of the Impact of a CPOE System on Nurse-physician Communication - A Mixed Method Study. *Methods Inf.Med.* 2009 May 15;48(4).
- (75) Ash JS, Bates DW. Factors and forces affecting EHR system adoption: report of a 2004 ACMI discussion. *J.Am.Med.Inform.Assoc.* 2005 Jan-Feb;12(1):8-12.
- (76) Bates DW, Kuperman G, Teich JM. Computerized physician order entry and quality of care. *Qual.Manag.Health Care* 1994 Summer;2(4):18-27.
- (77) Campbell EM, Sittig DF, Ash JS, Guappone KP, Dykstra RH. Types of unintended consequences related to computerized provider order entry. *J.Am.Med.Inform.Assoc.* 2006 Sep-Oct;13(5):547-556.
- (78) Norman DA. *The design of future things.* New York, NY: Basic Books; 2007.
- (79) Han YY, Carcillo JA, Venkataraman ST, Clark RS, Watson RS, Nguyen TC, et al. Unexpected increased mortality after implementation of a commercially sold computerized physician order entry system. *Pediatrics* 2005 Dec;116(6):1506-1512.
- (80) Nebeker JR, Hoffman JM, Weir CR, Bennett CL, Hurdle JF. High rates of adverse drug events in a highly computerized hospital. *Arch.Intern.Med.* 2005 May 23;165(10):1111-1116.
- (81) Weiner M, Gress T, Thiemann DR, Jenckes M, Reel SL, Mandell SF, et al. Contrasting views of physicians and nurses about an inpatient computer-based provider order-entry system. *J.Am.Med.Inform.Assoc.* 1999 May-Jun;6(3):234-244.
- (82) Ammenwerth E, Talmon J, Ash JS, Bates DW, Beuscart-Zephir MC, Duhamel A, et al. Impact of CPOE on mortality rates--contradictory findings, important messages. *Methods Inf.Med.* 2006;45(6):586-593.
- (83) Grol R. Personal paper. Beliefs and evidence in changing clinical practice. *BMJ* 1997 Aug 16;315(7105):418-421.
- (84) Rahimi B, Moberg A, Timpka T, Vimarlund V. Implementing an integrated computerized patient record system: Towards an evidence-based information system implementation practice in healthcare. *AMIA.Annu.Symp.Proc.* 2008:616-620.
- (85) Rahimi B, Vimarlund V, Timpka T. Health Information System Implementation: A Qualitative Meta-analysis. *J.Med.Syst.;* *J.Med.Syst.* 2008:1-10.
- (86) Hassett MM. Applications for health care information systems. In: "Englebardt SP", "Nelson R", editors. *Health care informatics : an interdisciplinary approach* St. Louis, Mo.: Mosby; 2002. p. 576.

**Dissertations**

**Linköping Studies in Science and Technology**

- No 14 **Anders Haraldsson:** A Program Manipulation System Based on Partial Evaluation, 1977, ISBN 91-7372-144-1.
- No 17 **Bengt Magnhagen:** Probability Based Verification of Time Margins in Digital Designs, 1977, ISBN 91-7372-157-3.
- No 18 **Mats Cedwall:** Semantisk analys av processbeskrivningar i naturligt språk, 1977, ISBN 91-7372-168-9.
- No 22 **Jaak Urmi:** A Machine Independent LISP Compiler and its Implications for Ideal Hardware, 1978, ISBN 91-7372-188-3.
- No 33 **Tore Risch:** Compilation of Multiple File Queries in a Meta-Database System 1978, ISBN 91-7372-232-4.
- No 51 **Erland Jungert:** Synthesizing Database Structures from a User Oriented Data Model, 1980, ISBN 91-7372-387-8.
- No 54 **Sture Hägglund:** Contributions to the Development of Methods and Tools for Interactive Design of Applications Software, 1980, ISBN 91-7372-404-1.
- No 55 **Pär Emanuelson:** Performance Enhancement in a Well-Structured Pattern Matcher through Partial Evaluation, 1980, ISBN 91-7372-403-3.
- No 58 **Bengt Johnsson, Bertil Andersson:** The Human-Computer Interface in Commercial Systems, 1981, ISBN 91-7372-414-9.
- No 69 **H. Jan Komorowski:** A Specification of an Abstract Prolog Machine and its Application to Partial Evaluation, 1981, ISBN 91-7372-479-3.
- No 71 **René Reboh:** Knowledge Engineering Techniques and Tools for Expert Systems, 1981, ISBN 91-7372-489-0.
- No 77 **Östen Oskarsson:** Mechanisms of Modifiability in large Software Systems, 1982, ISBN 91-7372-527-7.
- No 94 **Hans Lunell:** Code Generator Writing Systems, 1983, ISBN 91-7372-652-4.
- No 97 **Andrzej Lingas:** Advances in Minimum Weight Triangulation, 1983, ISBN 91-7372-660-5.
- No 109 **Peter Fritzson:** Towards a Distributed Programming Environment based on Incremental Compilation, 1984, ISBN 91-7372-801-2.
- No 111 **Erik Tengvald:** The Design of Expert Planning Systems. An Experimental Operations Planning System for Turning, 1984, ISBN 91-7372-805-5.
- No 155 **Christos Levcopoulos:** Heuristics for Minimum Decompositions of Polygons, 1987, ISBN 91-7870-133-3.
- No 165 **James W. Goodwin:** A Theory and System for Non-Monotonic Reasoning, 1987, ISBN 91-7870-183-X.
- No 170 **Zebo Peng:** A Formal Methodology for Automated Synthesis of VLSI Systems, 1987, ISBN 91-7870-225-9.
- No 174 **Johan Fagerström:** A Paradigm and System for Design of Distributed Systems, 1988, ISBN 91-7870-301-8.
- No 192 **Dimitër Driankov:** Towards a Many Valued Logic of Quantified Belief, 1988, ISBN 91-7870-374-3.
- No 213 **Lin Padgham:** Non-Monotonic Inheritance for an Object Oriented Knowledge Base, 1989, ISBN 91-7870-485-5.
- No 214 **Tony Larsson:** A Formal Hardware Description and Verification Method, 1989, ISBN 91-7870-517-7.
- No 221 **Michael Reinfrank:** Fundamentals and Logical Foundations of Truth Maintenance, 1989, ISBN 91-7870-546-0.
- No 239 **Jonas Löwgren:** Knowledge-Based Design Support and Discourse Management in User Interface Management Systems, 1991, ISBN 91-7870-720-X.
- No 244 **Henrik Eriksson:** Meta-Tool Support for Knowledge Acquisition, 1991, ISBN 91-7870-746-3.
- No 252 **Peter Eklund:** An Epistemic Approach to Interactive Design in Multiple Inheritance Hierarchies, 1991, ISBN 91-7870-784-6.
- No 258 **Patrick Doherty:** NML3 - A Non-Monotonic Formalism with Explicit Defaults, 1991, ISBN 91-7870-816-8.
- No 260 **Nahid Shahmehri:** Generalized Algorithmic Debugging, 1991, ISBN 91-7870-828-1.
- No 264 **Nils Dahlbäck:** Representation of Discourse-Cognitive and Computational Aspects, 1992, ISBN 91-7870-850-8.
- No 265 **Ulf Nilsson:** Abstract Interpretations and Abstract Machines: Contributions to a Methodology for the Implementation of Logic Programs, 1992, ISBN 91-7870-858-3.
- No 270 **Ralph Rönquist:** Theory and Practice of Tense-bound Object References, 1992, ISBN 91-7870-873-7.
- No 273 **Björn Fjellborg:** Pipeline Extraction for VLSI Data Path Synthesis, 1992, ISBN 91-7870-880-X.
- No 276 **Staffan Bonnier:** A Formal Basis for Horn Clause Logic with External Polymorphic Functions, 1992, ISBN 91-7870-896-6.

- No 277 **Kristian Sandahl:** Developing Knowledge Management Systems with an Active Expert Methodology, 1992, ISBN 91-7870-897-4.
- No 281 **Christer Bäckström:** Computational Complexity of Reasoning about Plans, 1992, ISBN 91-7870-979-2.
- No 292 **Mats Wirén:** Studies in Incremental Natural Language Analysis, 1992, ISBN 91-7871-027-8.
- No 297 **Mariam Kamkar:** Interprocedural Dynamic Slicing with Applications to Debugging and Testing, 1993, ISBN 91-7871-065-0.
- No 302 **Tingting Zhang:** A Study in Diagnosis Using Classification and Defaults, 1993, ISBN 91-7871-078-2.
- No 312 **Arne Jönsson:** Dialogue Management for Natural Language Interfaces - An Empirical Approach, 1993, ISBN 91-7871-110-X.
- No 338 **Simin Nadjm-Tehrani:** Reactive Systems in Physical Environments: Compositional Modeling and Framework for Verification, 1994, ISBN 91-7871-237-8.
- No 371 **Bengt Savén:** Business Models for Decision Support and Learning. A Study of Discrete-Event Manufacturing Simulation at Asea/ABB 1968-1993, 1995, ISBN 91-7871-494-X.
- No 375 **Ulf Söderman:** Conceptual Modelling of Mode Switching Physical Systems, 1995, ISBN 91-7871-516-4.
- No 383 **Andreas Kågedal:** Exploiting Groundness in Logic Programs, 1995, ISBN 91-7871-538-5.
- No 396 **George Fodor:** Ontological Control, Description, Identification and Recovery from Problematic Control Situations, 1995, ISBN 91-7871-603-9.
- No 413 **Mikael Petterson:** Compiling Natural Semantics, 1995, ISBN 91-7871-641-1.
- No 414 **Xinli Gu:** RT Level Testability Improvement by Testability Analysis and Transformations, 1996, ISBN 91-7871-654-3.
- No 416 **Hua Shu:** Distributed Default Reasoning, 1996, ISBN 91-7871-665-9.
- No 429 **Jaime Villegas:** Simulation Supported Industrial Training from an Organisational Learning Perspective - Development and Evaluation of the SSIT Method, 1996, ISBN 91-7871-700-0.
- No 431 **Peter Jonsson:** Studies in Action Planning: Algorithms and Complexity, 1996, ISBN 91-7871-704-3.
- No 437 **Johan Boye:** Directional Types in Logic Programming, 1996, ISBN 91-7871-725-6.
- No 439 **Cecilia Sjöberg:** Activities, Voices and Arenas: Participatory Design in Practice, 1996, ISBN 91-7871-728-0.
- No 448 **Patrick Lambrix:** Part-Whole Reasoning in Description Logics, 1996, ISBN 91-7871-820-1.
- No 452 **Kjell Orsborn:** On Extensible and Object-Relational Database Technology for Finite Element Analysis Applications, 1996, ISBN 91-7871-827-9.
- No 459 **Olof Johansson:** Development Environments for Complex Product Models, 1996, ISBN 91-7871-855-4.
- No 461 **Lena Strömbäck:** User-Defined Constructions in Unification-Based Formalisms, 1997, ISBN 91-7871-857-0.
- No 462 **Lars Degerstedt:** Tabulation-based Logic Programming: A Multi-Level View of Query Answering, 1996, ISBN 91-7871-858-9.
- No 475 **Fredrik Nilsson:** Strategi och ekonomisk styrning - En studie av hur ekonomiska styrsystem utformas och används efter företagsförvärv, 1997, ISBN 91-7871-914-3.
- No 480 **Mikael Lindvall:** An Empirical Study of Requirements-Driven Impact Analysis in Object-Oriented Software Evolution, 1997, ISBN 91-7871-927-5.
- No 485 **Göran Forslund:** Opinion-Based Systems: The Cooperative Perspective on Knowledge-Based Decision Support, 1997, ISBN 91-7871-938-0.
- No 494 **Martin Sköld:** Active Database Management Systems for Monitoring and Control, 1997, ISBN 91-7219-002-7.
- No 495 **Hans Olsén:** Automatic Verification of Petri Nets in a CLP framework, 1997, ISBN 91-7219-011-6.
- No 498 **Thomas Drakengren:** Algorithms and Complexity for Temporal and Spatial Formalisms, 1997, ISBN 91-7219-019-1.
- No 502 **Jakob Axelsson:** Analysis and Synthesis of Heterogeneous Real-Time Systems, 1997, ISBN 91-7219-035-3.
- No 503 **Johan Ringström:** Compiler Generation for Data-Parallel Programming Languages from Two-Level Semantics Specifications, 1997, ISBN 91-7219-045-0.
- No 512 **Anna Moberg:** Närhet och distans - Studier av kommunikationsmönster i satellitkontor och flexibla kontor, 1997, ISBN 91-7219-119-8.
- No 520 **Mikael Ronström:** Design and Modelling of a Parallel Data Server for Telecom Applications, 1998, ISBN 91-7219-169-4.
- No 522 **Niclas Ohlsson:** Towards Effective Fault Prevention - An Empirical Study in Software Engineering, 1998, ISBN 91-7219-176-7.
- No 526 **Joachim Karlsson:** A Systematic Approach for Prioritizing Software Requirements, 1998, ISBN 91-7219-184-8.
- No 530 **Henrik Nilsson:** Declarative Debugging for Lazy Functional Languages, 1998, ISBN 91-7219-197-x.
- No 555 **Jonas Hallberg:** Timing Issues in High-Level Synthesis, 1998, ISBN 91-7219-369-7.

- No 561 **Ling Lin:** Management of 1-D Sequence Data - From Discrete to Continuous, 1999, ISBN 91-7219-402-2.
- No 563 **Eva L Ragnemalm:** Student Modelling based on Collaborative Dialogue with a Learning Companion, 1999, ISBN 91-7219-412-X.
- No 567 **Jörgen Lindström:** Does Distance matter? On geographical dispersion in organisations, 1999, ISBN 91-7219-439-1.
- No 582 **Vanja Josifovski:** Design, Implementation and Evaluation of a Distributed Mediator System for Data Integration, 1999, ISBN 91-7219-482-0.
- No 589 **Rita Kovordányi:** Modeling and Simulating Inhibitory Mechanisms in Mental Image Re-interpretation - Towards Cooperative Human-Computer Creativity, 1999, ISBN 91-7219-506-1.
- No 592 **Mikael Ericsson:** Supporting the Use of Design Knowledge - An Assessment of Commenting Agents, 1999, ISBN 91-7219-532-0.
- No 593 **Lars Karlsson:** Actions, Interactions and Narratives, 1999, ISBN 91-7219-534-7.
- No 594 **C. G. Mikael Johansson:** Social and Organizational Aspects of Requirements Engineering Methods - A practice-oriented approach, 1999, ISBN 91-7219-541-X.
- No 595 **Jörgen Hansson:** Value-Driven Multi-Class Overload Management in Real-Time Database Systems, 1999, ISBN 91-7219-542-8.
- No 596 **Niklas Hallberg:** Incorporating User Values in the Design of Information Systems and Services in the Public Sector: A Methods Approach, 1999, ISBN 91-7219-543-6.
- No 597 **Vivian Vimarlund:** An Economic Perspective on the Analysis of Impacts of Information Technology: From Case Studies in Health-Care towards General Models and Theories, 1999, ISBN 91-7219-544-4.
- No 598 **Johan Jenvald:** Methods and Tools in Computer-Supported Taskforce Training, 1999, ISBN 91-7219-547-9.
- No 607 **Magnus Merkel:** Understanding and enhancing translation by parallel text processing, 1999, ISBN 91-7219-614-9.
- No 611 **Silvia Coradeschi:** Anchoring symbols to sensory data, 1999, ISBN 91-7219-623-8.
- No 613 **Man Lin:** Analysis and Synthesis of Reactive Systems: A Generic Layered Architecture Perspective, 1999, ISBN 91-7219-630-0.
- No 618 **Jimmy Tjäder:** Systemimplementering i praktiken - En studie av logiker i fyra projekt, 1999, ISBN 91-7219-657-2.
- No 627 **Vadim Engelson:** Tools for Design, Interactive Simulation, and Visualization of Object-Oriented Models in Scientific Computing, 2000, ISBN 91-7219-709-9.
- No 637 **Esa Falkenroth:** Database Technology for Control and Simulation, 2000, ISBN 91-7219-766-8.
- No 639 **Per-Arne Persson:** Bringing Power and Knowledge Together: Information Systems Design for Autonomy and Control in Command Work, 2000, ISBN 91-7219-796-X.
- No 660 **Erik Larsson:** An Integrated System-Level Design for Testability Methodology, 2000, ISBN 91-7219-890-7.
- No 688 **Marcus Bjärelund:** Model-based Execution Monitoring, 2001, ISBN 91-7373-016-5.
- No 689 **Joakim Gustafsson:** Extending Temporal Action Logic, 2001, ISBN 91-7373-017-3.
- No 720 **Carl-Johan Petri:** Organizational Information Provision - Managing Mandatory and Discretionary Use of Information Technology, 2001, ISBN-91-7373-126-9.
- No 724 **Paul Scerri:** Designing Agents for Systems with Adjustable Autonomy, 2001, ISBN 91 7373 207 9.
- No 725 **Tim Heyer:** Semantic Inspection of Software Artifacts: From Theory to Practice, 2001, ISBN 91 7373 208 7.
- No 726 **Pär Carlshamre:** A Usability Perspective on Requirements Engineering - From Methodology to Product Development, 2001, ISBN 91 7373 212 5.
- No 732 **Juha Takkinen:** From Information Management to Task Management in Electronic Mail, 2002, ISBN 91 7373 258 3.
- No 745 **Johan Åberg:** Live Help Systems: An Approach to Intelligent Help for Web Information Systems, 2002, ISBN 91-7373-311-3.
- No 746 **Rego Granlund:** Monitoring Distributed Teamwork Training, 2002, ISBN 91-7373-312-1.
- No 757 **Henrik André-Jönsson:** Indexing Strategies for Time Series Data, 2002, ISBN 917373-346-6.
- No 747 **Anneli Hagdahl:** Development of IT-supported Inter-organisational Collaboration - A Case Study in the Swedish Public Sector, 2002, ISBN 91-7373-314-8.
- No 749 **Sofie Pilemalm:** Information Technology for Non-Profit Organisations - Extended Participatory Design of an Information System for Trade Union Shop Stewards, 2002, ISBN 91-7373-318-0.
- No 765 **Stefan Holmlid:** Adapting users: Towards a theory of use quality, 2002, ISBN 91-7373-397-0.
- No 771 **Magnus Morin:** Multimedia Representations of Distributed Tactical Operations, 2002, ISBN 91-7373-421-7.
- No 772 **Pawel Pietrzak:** A Type-Based Framework for Locating Errors in Constraint Logic Programs, 2002, ISBN 91-7373-422-5.
- No 758 **Erik Berglund:** Library Communication Among Programmers Worldwide, 2002, ISBN 91-7373-349-0.
- No 774 **Choong-ho Yi:** Modelling Object-Oriented Dynamic Systems Using a Logic-Based Framework, 2002, ISBN 91-7373-424-1.

- No 779 **Mathias Broxvall:** A Study in the Computational Complexity of Temporal Reasoning, 2002, ISBN 91-7373-440-3.
- No 793 **Asmus Pandikow:** A Generic Principle for Enabling Interoperability of Structured and Object-Oriented Analysis and Design Tools, 2002, ISBN 91-7373-479-9.
- No 785 **Lars Hult:** Publika Informationstjänster. En studie av den Internetbaserade encyklopedins bruksegenskaper, 2003, ISBN 91-7373-461-6.
- No 800 **Lars Taxén:** A Framework for the Coordination of Complex Systems' Development, 2003, ISBN 91-7373-604-X
- No 808 **Klas Gäre:** Tre perspektiv på förväntningar och förändringar i samband med införande av informationssystem, 2003, ISBN 91-7373-618-X.
- No 821 **Mikael Kindborg:** Concurrent Comics - programming of social agents by children, 2003, ISBN 91-7373-651-1.
- No 823 **Christina Ölvingson:** On Development of Information Systems with GIS Functionality in Public Health Informatics: A Requirements Engineering Approach, 2003, ISBN 91-7373-656-2.
- No 828 **Tobias Ritzau:** Memory Efficient Hard Real-Time Garbage Collection, 2003, ISBN 91-7373-666-X.
- No 833 **Paul Pop:** Analysis and Synthesis of Communication-Intensive Heterogeneous Real-Time Systems, 2003, ISBN 91-7373-683-X.
- No 852 **Johan Moe:** Observing the Dynamic Behaviour of Large Distributed Systems to Improve Development and Testing - An Empirical Study in Software Engineering, 2003, ISBN 91-7373-779-8.
- No 867 **Erik Herzog:** An Approach to Systems Engineering Tool Data Representation and Exchange, 2004, ISBN 91-7373-929-4.
- No 872 **Aseel Berglund:** Augmenting the Remote Control: Studies in Complex Information Navigation for Digital TV, 2004, ISBN 91-7373-940-5.
- No 869 **Jo Skåmedal:** Telecommuting's Implications on Travel and Travel Patterns, 2004, ISBN 91-7373-935-9.
- No 870 **Linda Askenäs:** The Roles of IT - Studies of Organising when Implementing and Using Enterprise Systems, 2004, ISBN 91-7373-936-7.
- No 874 **Annika Flycht-Eriksson:** Design and Use of Ontologies in Information-Providing Dialogue Systems, 2004, ISBN 91-7373-947-2.
- No 873 **Peter Bunus:** Debugging Techniques for Equation-Based Languages, 2004, ISBN 91-7373-941-3.
- No 876 **Jonas Mellin:** Resource-Predictable and Efficient Monitoring of Events, 2004, ISBN 91-7373-956-1.
- No 883 **Magnus Bång:** Computing at the Speed of Paper: Ubiquitous Computing Environments for Healthcare Professionals, 2004, ISBN 91-7373-971-5
- No 882 **Robert Eklund:** Disfluency in Swedish human-human and human-machine travel booking dialogues, 2004. ISBN 91-7373-966-9.
- No 887 **Anders Lindström:** English and other Foreign Linguistic Elements in Spoken Swedish. Studies of Productive Processes and their Modelling using Finite-State Tools, 2004, ISBN 91-7373-981-2.
- No 889 **Zhiping Wang:** Capacity-Constrained Production-inventory systems - Modelling and Analysis in both a traditional and an e-business context, 2004, ISBN 91-85295-08-6.
- No 893 **Pernilla Qvarfordt:** Eyes on Multimodal Interaction, 2004, ISBN 91-85295-30-2.
- No 910 **Magnus Kald:** In the Borderland between Strategy and Management Control - Theoretical Framework and Empirical Evidence, 2004, ISBN 91-85295-82-5.
- No 918 **Jonas Lundberg:** Shaping Electronic News: Genre Perspectives on Interaction Design, 2004, ISBN 91-85297-14-3.
- No 900 **Mattias Arvola:** Shades of use: The dynamics of interaction design for sociable use, 2004, ISBN 91-85295-42-6.
- No 920 **Luis Alejandro Cortés:** Verification and Scheduling Techniques for Real-Time Embedded Systems, 2004, ISBN 91-85297-21-6.
- No 929 **Diana Szentivanyi:** Performance Studies of Fault-Tolerant Middleware, 2005, ISBN 91-85297-58-5.
- No 933 **Mikael Cäker:** Management Accounting as Constructing and Opposing Customer Focus: Three Case Studies on Management Accounting and Customer Relations, 2005, ISBN 91-85297-64-X.
- No 937 **Jonas Kvarnström:** TALplanner and Other Extensions to Temporal Action Logic, 2005, ISBN 91-85297-75-5.
- No 938 **Bourhane Kadmiry:** Fuzzy Gain-Scheduled Visual Servoing for Unmanned Helicopter, 2005, ISBN 91-85297-76-3.
- No 945 **Gert Jervan:** Hybrid Built-In Self-Test and Test Generation Techniques for Digital Systems, 2005, ISBN: 91-85297-97-6.
- No 946 **Anders Arpteg:** Intelligent Semi-Structured Information Extraction, 2005, ISBN 91-85297-98-4.
- No 947 **Ola Angelsmark:** Constructing Algorithms for Constraint Satisfaction and Related Problems - Methods and Applications, 2005, ISBN 91-85297-99-2.
- No 963 **Calin Curescu:** Utility-based Optimisation of Resource Allocation for Wireless Networks, 2005. ISBN 91-85457-07-8.
- No 972 **Björn Johansson:** Joint Control in Dynamic Situations, 2005, ISBN 91-85457-31-0.
- No 974 **Dan Lawesson:** An Approach to Diagnosability Analysis for Interacting Finite State Systems, 2005, ISBN 91-85457-39-6.
- No 979 **Claudiu Duma:** Security and Trust Mechanisms for Groups in Distributed Services, 2005, ISBN 91-85457-54-X.
- No 983 **Sorin Manolache:** Analysis and Optimisation of Real-Time Systems with Stochastic Behaviour, 2005, ISBN 91-85457-60-4.

- No 986 **Yuxiao Zhao:** Standards-Based Application Integration for Business-to-Business Communications, 2005, ISBN 91-85457-66-3.
- No 1004 **Patrik Haslum:** Admissible Heuristics for Automated Planning, 2006, ISBN 91-85497-28-2.
- No 1005 **Aleksandra Tešanovic:** Developing Reusable and Reconfigurable Real-Time Software using Aspects and Components, 2006, ISBN 91-85497-29-0.
- No 1008 **David Dinka:** Role, Identity and Work: Extending the design and development agenda, 2006, ISBN 91-85497-42-8.
- No 1009 **Iakov Nakhimovski:** Contributions to the Modeling and Simulation of Mechanical Systems with Detailed Contact Analysis, 2006, ISBN 91-85497-43-X.
- No 1013 **Wilhelm Dahllöf:** Exact Algorithms for Exact Satisfiability Problems, 2006, ISBN 91-85523-97-6.
- No 1016 **Levon Saldamli:** PDEModelica - A High-Level Language for Modeling with Partial Differential Equations, 2006, ISBN 91-85523-84-4.
- No 1017 **Daniel Karlsson:** Verification of Component-based Embedded System Designs, 2006, ISBN 91-85523-79-8.
- No 1018 **Ioan Chisalita:** Communication and Networking Techniques for Traffic Safety Systems, 2006, ISBN 91-85523-77-1.
- No 1019 **Tarja Susi:** The Puzzle of Social Activity - The Significance of Tools in Cognition and Cooperation, 2006, ISBN 91-85523-71-2.
- No 1021 **Andrzej Bednarski:** Integrated Optimal Code Generation for Digital Signal Processors, 2006, ISBN 91-85523-69-0.
- No 1022 **Peter Aronsson:** Automatic Parallelization of Equation-Based Simulation Programs, 2006, ISBN 91-85523-68-2.
- No 1030 **Robert Nilsson:** A Mutation-based Framework for Automated Testing of Timeliness, 2006, ISBN 91-85523-35-6.
- No 1034 **Jon Edvardsson:** Techniques for Automatic Generation of Tests from Programs and Specifications, 2006, ISBN 91-85523-31-3.
- No 1035 **Vaida Jakoniene:** Integration of Biological Data, 2006, ISBN 91-85523-28-3.
- No 1045 **Genevieve Gorrell:** Generalized Hebbian Algorithms for Dimensionality Reduction in Natural Language Processing, 2006, ISBN 91-85643-88-2.
- No 1051 **Yu-Hsing Huang:** Having a New Pair of Glasses - Applying Systemic Accident Models on Road Safety, 2006, ISBN 91-85643-64-5.
- No 1054 **Åsa Hedenskog:** Perceive those things which cannot be seen - A Cognitive Systems Engineering perspective on requirements management, 2006, ISBN 91-85643-57-2.
- No 1061 **Cécile Åberg:** An Evaluation Platform for Semantic Web Technology, 2007, ISBN 91-85643-31-9.
- No 1073 **Mats Grindal:** Handling Combinatorial Explosion in Software Testing, 2007, ISBN 978-91-85715-74-9.
- No 1075 **Almut Herzog:** Usable Security Policies for Runtime Environments, 2007, ISBN 978-91-85715-65-7.
- No 1079 **Magnus Wahlström:** Algorithms, measures, and upper bounds for satisfiability and related problems, 2007, ISBN 978-91-85715-55-8.
- No 1083 **Jesper Andersson:** Dynamic Software Architectures, 2007, ISBN 978-91-85715-46-6.
- No 1086 **Ulf Johansson:** Obtaining Accurate and Comprehensible Data Mining Models - An Evolutionary Approach, 2007, ISBN 978-91-85715-34-3.
- No 1089 **Traian Pop:** Analysis and Optimisation of Distributed Embedded Systems with Heterogeneous Scheduling Policies, 2007, ISBN 978-91-85715-27-5.
- No 1091 **Gustav Nordh:** Complexity Dichotomies for CSP-related Problems, 2007, ISBN 978-91-85715-20-6.
- No 1106 **Per Ola Kristensson:** Discrete and Continuous Shape Writing for Text Entry and Control, 2007, ISBN 978-91-85831-77-7.
- No 1110 **He Tan:** Aligning Biomedical Ontologies, 2007, ISBN 978-91-85831-56-2.
- No 1112 **Jessica Lindblom:** Minding the body - Interacting socially through embodied action, 2007, ISBN 978-91-85831-48-7.
- No 1113 **Pontus Wärnestål:** Dialogue Behavior Management in Conversational Recommender Systems, 2007, ISBN 978-91-85831-47-0.
- No 1120 **Thomas Gustafsson:** Management of Real-Time Data Consistency and Transient Overloads in Embedded Systems, 2007, ISBN 978-91-85831-33-3.
- No 1127 **Alexandru Andrei:** Energy Efficient and Predictable Design of Real-time Embedded Systems, 2007, ISBN 978-91-85831-06-7.
- No 1139 **Per Wikberg:** Eliciting Knowledge from Experts in Modeling of Complex Systems: Managing Variation and Interactions, 2007, ISBN 978-91-85895-66-3.
- No 1143 **Mehdi Amirijoo:** QoS Control of Real-Time Data Services under Uncertain Workload, 2007, ISBN 978-91-85895-49-6.
- No 1150 **Sanny Syberfeldt:** Optimistic Replication with Forward Conflict Resolution in Distributed Real-Time Databases, 2007, ISBN 978-91-85895-27-4.
- No 1155 **Beatrice Alenljung:** Envisioning a Future Decision Support System for Requirements Engineering - A Holistic and Human-centred Perspective, 2008, ISBN 978-91-85895-11-3.
- No 1156 **Artur Wilk:** Types for XML with Application to Xcerpt, 2008, ISBN 978-91-85895-08-3.
- No 1183 **Adrian Pop:** Integrated Model-Driven Development Environments for Equation-Based Object-Oriented Languages, 2008, ISBN 978-91-7393-895-2.
- No 1185 **Jörgen Skågeby:** Gifting Technologies - Ethnographic Studies of End-users and Social Media Sharing, 2008, ISBN 978-91-7393-892-1.
- No 1187 **Imad-Eldin Ali Abugessaisa:** Analytical tools

and information-sharing methods supporting road safety organizations, 2008, ISBN 978-91-7393-887-7.

No 1204 **H. Joe Steinhauer:** A Representation Scheme for Description and Reconstruction of Object Configurations Based on Qualitative Relations, 2008, ISBN 978-91-7393-823-5.

No 1222 **Anders Larsson:** Test Optimization for Core-based System-on-Chip, 2008, ISBN 978-91-7393-768-9.

No 1238 **Andreas Borg:** Processes and Models for Capacity Requirements in Telecommunication Systems, 2009, ISBN 978-91-7393-700-9.

No 1240 **Fredrik Heintz:** DyKnow: A Stream-Based Knowledge Processing Middleware Framework, 2009, ISBN 978-91-7393-696-5.

No 1241 **Birgitta Lindström:** Testability of Dynamic Real-Time Systems, 2009, ISBN 978-91-7393-695-8.

No 1244 **Eva Blomqvist:** Semi-automatic Ontology Construction based on Patterns, 2009, ISBN 978-91-7393-683-5.

No 1249 **Rogier Woltjer:** Functional Modeling of Constraint Management in Aviation Safety and Command and Control, 2009, ISBN 978-91-7393-659-0.

No 1260 **Gianpaolo Conte:** Vision-Based Localization and Guidance for Unmanned Aerial Vehicles, 2009, ISBN 978-91-7393-603-3.

No 1262 **AnnMarie Ericsson:** Enabling Tool Support for Formal Analysis of ECA Rules, 2009, ISBN 978-91-7393-598-2.

No 1266: **Jiri Trnka:** Exploring Tactical Command and Control: A Role-Playing Simulation Approach, 2009, ISBN 978-91-7393-571-5.

No 1268: **Bahlol Rahimi:** Supporting Collaborative Work through ICT - How End-users Think of and Adopt Integrated Health Information Systems, 2009, ISBN 978-91-7393-550-0.

### Linköping Studies in Statistics

No 9 **Davood Shahsavani:** Computer Experiments Designed to Explore and Approximate Complex Deterministic Models, 2008, ISBN 978-91-7393-976-8.

No 10 **Karl Wahlin:** Roadmap for Trend Detection and Assessment of Data Quality, 2008, ISBN: 978-91-7393-792-4

### Linköping Studies in Information Science

No 1 **Karin Axelsson:** Metodisk systemstrukturering - att skapa samstämmighet mellan informationssystemarkitektur och verksamhet, 1998. ISBN-9172-19-296-8.

No 2 **Stefan Cronholm:** Metodverktyg och användbarhet - en studie av datorstödd metodbaserad systemutveckling, 1998. ISBN-9172-19-299-2.

No 3 **Anders Avdic:** Användare och utvecklare - om anveckling med kalkylprogram, 1999. ISBN-91-7219-606-8.

No 4 **Owen Eriksson:** Kommunikationskvalitet hos

informationssystem och affärsprocesser, 2000. ISBN 91-7219-811-7.

No 5 **Mikael Lind:** Från system till process - kriterier för processbestämning vid verksamhetsanalys, 2001, ISBN 91-7373-067-X

No 6 **Ulf Melin:** Koordination och informationssystem i företag och nätverk, 2002, ISBN 91-7373-278-8.

No 7 **Pär J. Ågerfalk:** Information Systems Actability - Understanding Information Technology as a Tool for Business Action and Communication, 2003, ISBN 91-7373-628-7.

No 8 **Ulf Seigerroth:** Att förstå och förändra systemutvecklingsverksamheter - en taxonomi för metautveckling, 2003, ISBN91-7373-736-4.

No 9 **Karin Hedström:** Spår av datoriseringens värden - Effekter av IT i äldreomsorg, 2004, ISBN 91-7373-963-4.

No 10 **Ewa Braf:** Knowledge Demanded for Action - Studies on Knowledge Mediation in Organizations, 2004, ISBN 91-85295-47-7.

No 11 **Fredrik Karlsson:** Method Configuration - method and computerized tool support, 2005, ISBN 91-85297-48-8.

No 12 **Malin Nordström:** Styrbar systemförvaltning - Att organisera systemförvaltningsverksamhet med hjälp av effektiva förvaltningsobjekt, 2005, ISBN 91-85297-60-7.

No 13 **Stefan Holgersson:** Yrke: POLIS - Yrkeskunskap, motivation, IT-system och andra förutsättningar för polisarbete, 2005, ISBN 91-85299-43-X.

No 14 **Benneth Christiansson, Marie-Therese Christiansson:** Mötet mellan process och komponent - mot ett ramverk för en verksamhetsnära kravspecifikation vid anskaffning av komponentbaserade informationssystem, 2006, ISBN 91-85643-22-X.