# UNDERSTANDING IMPLEMENTATION: A SOCIOTECHNICAL APPRAISAL OF THE INTRODUCTION OF COMPUTERIZED PHYSICIAN ORDER ENTRY SYSTEMS IN DUTCH AND AMERICAN HOSPITALS

# UNDERSTANDING IMPLEMENTATION: A SOCIOTECHNICAL APPRAISAL OF THE INTRODUCTION OF COMPUTERIZED PHYSICIAN ORDER ENTRY SYSTEMS IN DUTCH AND AMERICAN HOSPITALS

## IMPLEMENTATIE: EEN SOCIOTECHNISCHE STUDIE NAAR DE INVOERING VAN GEAUTOMATISEERDE ORDERCOMMUNICATIE SYSTEMEN IN NEDERLANDSE EN AMERIKAANSE ZIEKENHUIZEN

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# INHOUDSOPGAVE

# INTRODUCTION

"Developing a comprehensive medical information system was a more complex task than putting a man on the moon had been," writes Morris Collen in the conclusion of his book about the history of medical informatics in the United States [1]. This single sentence aptly illustrates the technological and organizational complexity of introducing an information system into hospitals that Collen describes as one of the "most complex institutions created by humans."

A key characteristic of implementing information systems is that organizational changes are an integral part of it. Unfortunately, however, the changes are not always for the better, and more often than not, the performance of organizations is worse after a system has been installed than before. The natural tendency is then to conclude that the system was somehow badly designed. In 1975, when the design and operation of information systems were considered primarily technical activities, Henry C. Lucas, Jr. wrote about failing systems: "However, all our experience suggests that the primary cause for system failure has been organizational behavior problems [2]." Thirty years of research has increased our understanding of information systems in organizational contexts; yet, the record of successful systems is still dismal [3]. Clinical information systems are particularly hard to implement because not only do they affect health care organizations as a whole but also the work of health professionals who pride themselves on their professional autonomy.

The research described in this thesis arose in the summer of 1997 from a question of a nurse director at Radboud University Medical Center in Nijmegen. He asked me whether I was interested to study their new clinical information system. He described the system as a computerized order entry system that would allow doctors to enter their orders. The project team responsible for the implementation could use some feedback, and he thought this would be a good thesis subject. I saw a golden opportunity to document a system from its initial development to its full clinical use. It was an interesting system because it had clinical work at its focus unlike other hospital information systems, which at that time were primarily designed for clerical purposes such as patient administration and billing. It would be a complex project, affecting 5000 professionals, including physicians. In its first stages, the implementation seemed to go well and there were no signs of the failure that was to come two years later.

The study then is about implementation and about clinical systems. Implementation encompasses the trajectory of introducing an information system from the idea that such a system is needed to address perceived organizational problems up to its use in work practices. In order to understand the outcome of an implementation trajectory one needs to go back in history to identify important events that influenced the course of implementation, and to follow in time how the information technology was introduced and installed. Clinical systems, such as electronic patient records, are meant to be used by clinicians to address their information needs. This study focuses on computerized physician order entry (CPOE) systems. CPOE systems are a class of clinical systems that help a clinician enter medical orders electronically. Medical orders are key in the delivery of health care in the sense that they are the result of making clinical decisions. For example, when a patient needs to be treated with medication, a physician writes a drug order. The written order will be received by the pharmacy that will check the request, prepare a medication list for the patient and prepare and package a dose. The nurse then can administer the drug to the patient. A CPOE system can allow the physician to enter orders directly into a computer, bypassing handwritten communication and the need for manually copying information from one paper to another. [4]. Many benefits are attributed to CPOE systems. They may eliminate ambiguities caused by illegibility of handwritten orders or by incomplete orders. They can make physicians cost-conscious by keeping prescribing practices in line with a hospital's established formulary. Reminders can be generated alerting physicians about dosages, drug-drug interactions, adverse drug events and drug allergies. It may save precious physician time by reducing unnecessary telephone calls. CPOE systems, then, have been identified as the technology that can help reduce medical errors and increase patient safety. The respected Institute of Medicine of the National Academy of Sciences released two reports in 2000 en 2001 that urge the adoption of CPOE systems in hospitals [5, 6].

Four years later, however, Joan Ash and her colleagues found that still less than 10% of the American hospitals have implemented CPOE [7]. The large gap between the perceived benefits and actual use testifies to the great difficulty of getting such systems to work in clinical practice.

The study of system implementation cannot be separated of an understanding of its organizational context. The sociotechnical approach I use in this thesis stresses the importance of the interrelation between technology and its social environment [8]. The sociotechnical approach is not so much a delineated theory; it is rather a perspective, developed within information systems research, technology studies and computer supported cooperative work that allows the researcher to explore a variety of aspects of the interrelation [9]. The relevant details of this approach will be addressed in the chapters that follow, yet three general aspects are important to treat here.

First, the sociotechnical approach acknowledges that the roles and tasks of health professionals are tightly interwoven with each other and their environments. Material artifacts, such as a paper form, a room design or a computer system structure the work of health professionals, distribute their responsibilities, and determine the nature of their relationships. For example, a patient assessment form will structure how a nurse will examine a patient and what information she will write down. Replacing the form by a computer-based assessment system will change how the nurse will examine the patient. On paper the nurse might ignore entries that she would consider not relevant for her assessment of the patient's health. A computer might force her to enter data in all fields, even if they are not relevant.

Second, medical work is a highly collective and collaborative process. In a classic study Anselm Strauss and his co-authors describe how the delivery of patient care can be characterized as *managing a patient illness trajectory.* This includes all activities that need to be done to make patient care possible [10]. Medical work is very pragmatic and fluid because its response to unexpected events or contingencies that are so common in health care.

Third, in order to judge the value of an information system in practice it is necessary to have a deep empirical insight into the work practices in which an information system will be used. Qualitative research methods need to be employed to grasp the intricate relations between health care professionals and an information system [11]. Methods include, but are not limited to observational studies, interviews and document studies. Observational studies provide a direct link with medical work activities that professionals do such as how they use a computer, how they enter medical orders and how they communicate with others while entering data. Interviews provide insight in people's perception of facts and are mostly done when there is often no other way to obtain data, for example about events that happened in the past. Documents constitute a rich source of information about organizations and their constituents. In this study they encompassed decision and implementation documents, minutes of meetings, user manuals, news reports, magazine articles and scientific journal articles. Finally, combining different data sources provided a means to validation.

The aim of the study described in this thesis is to understand the implementation of computerized physician order entry (CPOE) systems in hospitals from a sociotechnical perspective.

The study consists of three parts. The first part describes an implementation model of clinical systems in health care organizations and forms a backdrop against which the case studies are posited. The same model underlies the contents of a postgraduate master course of health information management targeting professionals who wish to use the benefits of information technology to realize changes in health care [12]. The second part consists of two in-depth studies of the introduction of CPOE systems in Radboud University Medical

Center in Nijmegen and Atrium Medical Center in Heerlen aiming at understanding the complex dynamics of implementation. In the United States CPOE systems have been implemented more widely. David Bates at Brigham and Women's Hospital in Boston and Joan Ash at Oregon Health & Science University in Portland, Ore, have respectively studied clinical and organizational aspects of CPOE systems [13, 14]. Therefore, the last part of this study aims to understand the findings of the case studies in a wider context of comparing with the implementation of similar systems in the Netherlands and United States. Furthermore, by interviewing high-level CPOE experts I have tried to assess the implications of CPOE systems for professional collaboration and workflow and their impact on quality of care. This part of the study was carried out in 2003 and 2004 when I was a visiting scientist in the Department of Medical Informatics and Clinical Epidemiology of Oregon Health & Science University. The following questions were addressed in this study:

What are the general characteristics of an implementation trajectory of a clinical information system?

How can the outcomes of the implementation of a CPOE system in a hospital explained from a sociotechnical perspective?

What factors from a medical work perspective explain the different outcomes of the implementation of a computerized physician order entry system in two Dutch hospitals?

How do implementation strategies of Dutch and American hospitals compare and how are physicians involved?

How can the perception of CPOE experts about workflow and professional collaboration and their impact on the quality of care extend the understanding of CPOE systems?

These questions will be addressed in the next six chapters. Chapter 1 describes the general characteristics of the implementation of a clinical information system. It presents a model of stages that can be discerned and depicts how a change manager needs to interact with the health care system and medical work in particular to bring about change. It proposes case-based studies that offer a systemic description of a complex and messy world of information systems in practice.

Chapter 2 presents a detailed description and analysis of the implementation of a CPOE system in Radboud University Medical Center in Nijmegen, the Netherlands. It argues how insights from social studies of science and technology can help to understand an implementation process and the specific outcomes described in this case. The case study forms the core of the thesis.

Chapter 3 expands the understanding to the analysis of the outcomes of the implementation of a CPOE system in two hospitals. The hospitals both used the same system, yet the outcomes were different.

Chapter 4 and 5 present the results of an international, cross-site qualitative study of the implementation of CPOE systems in the Netherlands and USA. The aim of the study is to understand and explain the resemblances and differences of implementing CPOE systems. Chapter 4 addresses the implementation strategies and chapter 5 focuses on the involvement of physicians in the process.

Chapter 6 reports the results of interviews with CPOE experts to combine their rich experience and insights with insights from medical sociology and the field of computer supported cooperative work to enhance the general understanding of CPOE in terms of professional collaboration and workflow and its impact on quality of care.

The thesis ends with a general conclusion that summarizes and draws the findings together.

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# CHAPTER 1

## USING A DESCRIPTIVE MODEL OF CHANGE WHEN IMPLEMENTING LARGE-SCALE CLINICAL INFORMATION SYSTEMS TO IDENTIFY PRIORITIES FOR FURTHER RESEARCH

Jos Aarts, Victor Peel


### SUMMARY

In this paper we identify domains for research based on a model that describes the stages of change when designing and implementing large-scale information and communication technology throughout a health care organization. We use the model in the case of the electronic patient record systems.
We suggest that the research agenda should include approaches from the social and business sciences.


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## 1. Introduction

The design and implementation of information systems in health care is a complex process that must address the issues of information systems, the prospective user(s) and organizational context and adequacy.

Although complex in its totality, some aspects of medical information systems are well understood. Over thirty years of research in medical informatics has contributed to a deep understanding of the nature of applications that are considered relevant for health care. Without being unjust to the rich and diverse medical informatics community one can say that representation of knowledge and the means by which it is interpreted has been the core of this research. There is an understanding that the user is an important factor in the study of medical informatics, but the literature has been focused largely upon the human-machine interaction. In strategy formulation and project management there is a substantial literature in the non-health care sector. Education about designing and implementing information systems in health care has largely been based on training of craft knowledge and is poorly substantiated by the results of scientific research.

The fuller research agenda proposed here does recognize the need for more research on human-machine interaction of clinical information systems because the progress in the development of graphical user-interfaces and speech input demands careful examination of its consequences in a health care context. However, the main focus of this paper is organizational, because there is an increased recognition that the organizational context is an important determinant for successful clinical information systems. Increasingly failures of clinical information systems are attributed to organizational factors [1, 2]. Technical faults in information systems have been reported to account for failure in 20% of the cases. The description of the failures is mostly case based and anecdotal, and an analyzing framework is not available.

There is still little reported research on organizational issues in the medical informatics community. The organizational 'grand challenge' in medical informatics to identify techniques to ease the incorporation of information technology into organizations looks increasingly narrow in its scope but even more urgent [3]. It also presupposes that the organization is fixed while the technology is changing.

## 2. Lessons from evaluation

One could argue that evaluation research of medical information systems will shed light on potential shortcomings. But most evaluation studies have been limited to technical performance or cost-effectiveness assessments and do not take a broader view. Some authors go even as far as to plea for controlled clinical trials (CCT's) of clinical information systems in the 'real world' as a method to assess the impact of clinical information systems in practice [4]. Not only are there theoretical arguments against this but a recent Finnish study shows unequivocally how difficult it is to assess the use of computerized medical records by primary care physicians when so many compounding social factors are involved [5]. In a review article Forsythe and Buchanan list five arguments that limits the usefulness of CCT's and proposes some general questions to broaden the approach to evaluating medical information systems [6]. Their arguments include the exclusion of subjective reactions to information systems, the focus on technical factors, the deletion of the social, and the quantitative and formal bias towards evaluation. The general questions all deal with the inclusion of context (user, stakeholders, the location of use and the social network, organization, judgment). These questions elude the formal CCT approach. It is clear that as evaluation studies increase their scope as well as their depth, they will provide more insight but relatively few advance our understanding of the organizational factors involved.

What makes the study of the organizational impact so difficult? We think that three reasons are important. The first has to do with the paradigm of experimental hypothesis testing which pervades research in clinical medicine and medical informatics.

Quantitative methods are predominant in this paradigm. Researchers in these areas mostly conduct their research in a controlled environment of a laboratory. Even when they go out and test a system in a clinical setting they seek to replicate laboratory conditions. The aim is to uncover the 'universal truth,' which lies hidden in the complex world. The second reason is related to the intrinsic complexity of the organizational context. Questions arise for example how factors like culture, power, and group relationships can influence not just the use but also the design and purchase of an information system. These and many more questions are hard to tackle without qualitative approaches, which are not part and parcel of the research toolkit of clinical researchers. It is not even clear what research method is best suited to address a particular organizational problem. An aspect of the complexity of the organizational context is the need of a multi-disciplinary approach. When the same problem is being viewed from different angles a richer picture and better understanding is available. The third reason is that the organizational context of a project may change over time and that other issues may become important.

Therefore we have developed a model of the stages of change, which can be discerned during the design and implementation of an information system in a health care organization. The model is extensively described in [7]. The model identifies at each stage the interaction of the design and implementation process with clinical work. By explicitly identifying such interactions with clinical work it is possible to focus on the research that would illuminate the nature of these interactions.

## 3. Identifying research priorities

This paper uses the model as a framework to locate previous research into the human and organizational issues involved in the implementation of complex health information systems and to identify future research priorities. We discuss each stage in turn (see fig. 1).

### *3.1 Assessing*

A deep understanding of the context in which clinical work is occurring is increasingly recognized as requisite for the successful implementation of an information system. More specifically hospitals are changing and becoming more and more a link in the chain of care delivery. Within hospitals the delivery of care is increasingly being organized around the patient. This will profoundly change the way that the care process is organized and how clinicians collaborate. This will influence how, when and for what purpose information will be used. Although changes take place in the processes of care, clinicians will still base their decisions on professional standards. How clinical work is done is highly localized. It is determined by professional peers and the social arrangements within the clinician's group. Therefore the interests of the organization and the individual clinician may not converge. Qualitative research methods (such as participatory observation and ethnographic studies) are necessary to elicit and understand these arrangements and behaviors and the impact that introducing information system may have on them.

Surprisingly very little research has been reported in respect of the rationale for such major organizational changes, realignments and mergers between health care organizations [8]. This seems to be not the result of captured experience and understanding of how changes might work out, but of political and economic imperatives. The lack of detailed knowledge as to how these changes might affect clinical work means also that we do not understand how information systems might be best integrated into the new forms and models of organization of the health care system, other than at the anecdotal level. The introduction of an information system can be considered as a process of structuration that will impose constraints on the arrangements and behaviors of actors.

Barley suggests how institutional theory and structuration theory can be fused for an empirical study of the links between organizations and actions [9]. With his approach he was able to show how the introduction of modern imaging technology changed professional dominance in radiology departments [10].

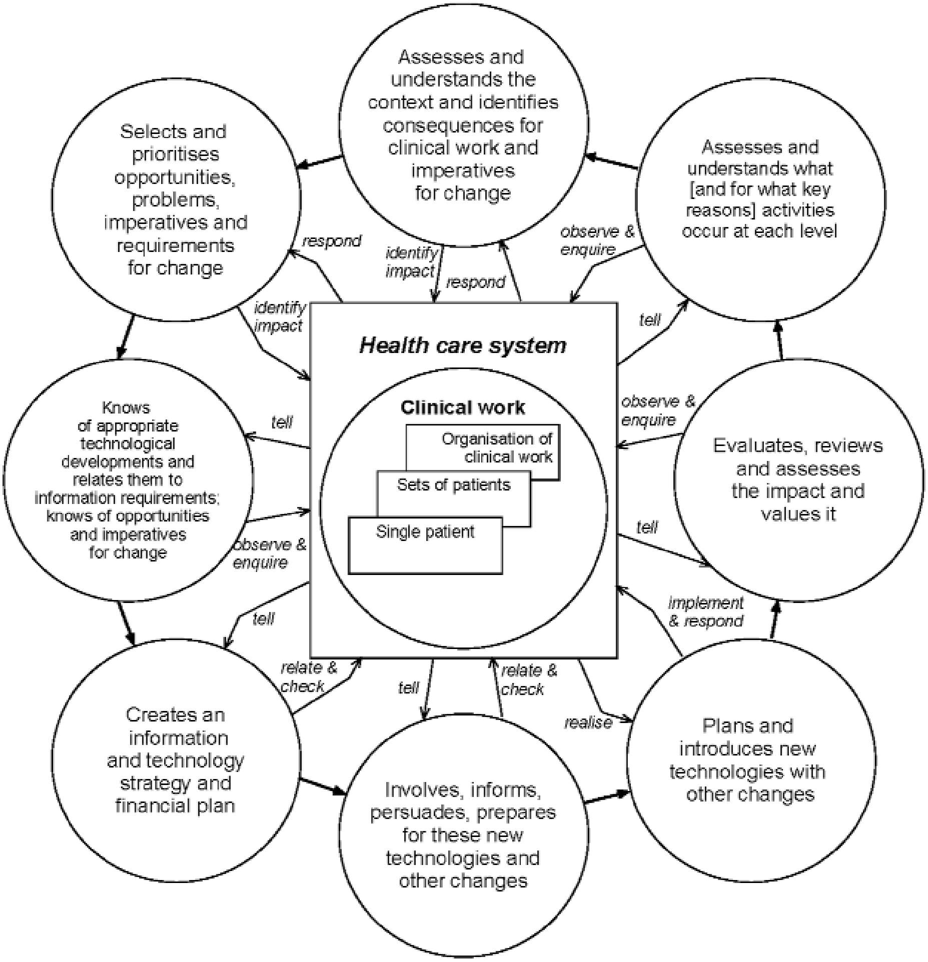


*Figure 1 - A model of the stages of changes, which can be discerned during the design and implementation of a clinical information system and the activities the change manager.*

Studies of organizational change entail two kinds of questions: 'What are the antecedents or consequences of changes in organizational forms or administrative practices?' and 'How does an organizational change emerge, develop, grow or terminate over time?' There is now a growing interest in studying the second question, which recognizes the temporal sequence of events. The shift towards the second question calls for longitudinal field research methods to study processes of organizational change [11].

### *3.2 Selecting and prioritizing*

We also have little understanding how the mechanisms of prioritization, funding and selection of systems work and they determine what will be implemented, with what kind of support, dissention or compromise and how that might affect the success of the new system. Analysis of the power relationships between stakeholders might well point the way to better understanding [12].

### *3.3 Knowing of appropriate technologies*

We acknowledge that advances in information and communication technologies can have a profound influence and because of that much medical informatics research relates to leading edge technology. However, technology assessment projects have so far been largely focused on the usability rather than the impact of these technologies on patient care and its outcomes [13]. In practice as systems are increasingly implemented across large organizations such as hospitals or even health care systems, there is a need to implement appropriate but also proven technologies. There are risks in 'bleeding' edge technologies, such as proneness to software malfunctioning, but proven technologies may impede rather than assist best clinical practice by hindering technological innovation at the bedside or meeting the practical immediate needs of a particular clinical discipline. The central question is therefore what is meant by 'appropriate' technologies and what do we know about both risks in order to minimize them.

The two most important arguments for implementing clinical systems are that they will enhance the quality and cost-effective-ness of patient care. Cost and benefit modeling for information systems has been largely restricted to business case approaches, which concentrate on investments and operational costs [14]. There is little recent research into how cost reduction goals are to be achieved and cost-effectiveness results or on the adequacy of valuation approaches to costs and benefits [15]. Often implementation of systems is leading to additional costs that have not been accounted for. Some authors consider the increase of costs even as an inevitable result of introducing new technologies. System costs may decrease when technologies become more mature but they often give rise to new applications and costs which where not envisaged before

[16]. The phenomenon that the massive introduction of computers has not led to increased economic gains has become known as the 'productivity paradox' [17]. It is also possible that increased productivity increases demand, activity and total costs. It is clear that more research is needed, because our understanding of cost-effectiveness and cost-benefits in relation to such systems is inadequate.

The process of implementing requires eliciting stakeholder support from the first conception of the project. The stakeholders will include not only prospective users, but also founders and people who can act on behalf of the team as power brokers to gain and sustain necessary support [18]. Again, more knowledge about the nature of these processes and particular the process of recovery if support breaks down, is crucial for the management of such implementations in large organizations when the total process may take several years.

### *3.4 Involving people, planning and introducing*

Health ICT project management has been for long time associated with the application of formal methods to achieve a particular goal with an agreed allocation of human, financial and material resources and a set time frame. Instruments of control such as formal time planning schedules (PERT and Gantt charts), project management tools (PROMPT) or accounting methods have been attributed great value. However, recent research shows that resorting to an increased use of instrumental control methods in project management when a project is taking a wrong course increases not decreases the chance of failure [19]. The need to consider such projects in a more flexible way recognizes the often unpredictable consequence of the way a new system interacts with organizations and humans

### *3.5 Evaluating*

The need for more work on the evaluation of impact, costs and benefits has been raised earlier in this paper. Although the model depicts it at the end of the implementation process, we emphasize that using lessons learned from previous failures and successes should be designed into the change process at the beginning of each new project.

## 4. The case of an EPR system as an illustration

With the help of the model we can identify the current gaps in our knowledge about the development and implementation of the electronic patient record system and point to new directions of research. The need for an EPR system has been brought forward since the late fifties as a solution for the ever increasing amount of medical knowledge, the growing disorder of the paper-based medical record and the variations in physician practice [20, 21].

Several studies in the 1960's enumerated the problems experienced with the paper-based record such as availability when needed, accessibility, completeness, comprehensiveness and readability [22]. In the seventies and eighties the desire to curb the growth of costs of health care delivery, obtain better value for money and the growing demand of the general public for quality care prompted the Institute of Medicine to publish a report on the computer-based patient record. Changes in health care are shifting towards managed care and rely on greater expectations of outcomes research and evidence based medicine. According to the updated report the EPR should be the essential technology for the health care system [23]. We observe here how the context of the health care system is considered as an impetus to design, implement and use EPR systems. We do not know however how the proposed changes will influence the actual development and use of EPR systems because of uncertainties involved with introduction of these changes and the slow adoption by health care professionals. The objectives of senior health policy makers and senior hospital management to introduce an EPR system may well diverge from those of clinicians.

However, the extent of use of such a computerized system by clinicians is modest. Apparently other factors inhibit the widespread use of the EPR. Several authors state technological factors, such as user interface design and the fact that many electronic data sources reside on different systems [24]. Few authors until relatively recently have suggested that social issues in the clinical environment may be a substantial inhibitor. Social factors may include collaboration patterns, the reluctance for clinical audit, source of funding reimbursement models, and the practical and social role that the paper-based record may play [25].

A 35-year longitudinal study showed the success of the use of structured flow sheets as part of the medical record and the gradual introduction of computer technology to support specific tasks [26]. Nordyke and Kulikowski write, "We maintain that success comes from choosing a level of technology that matches the information needs of a clinical practice, rather than adopting whatever current technology has to offer regardless of the clinical needs."

In short, referring to the model of fig. 1 we see that most research on EPR systems is related to the technical domain, while the changing health care context is taken for granted as an impetus that the use of these systems would increase in the future. Social and organizational factors, which are more important in the remaining stages of the model, are only dealt with in relatively few papers [27].

## Conclusion

Our model does not claim that the social factors are more important than others, but seeks to identify such domains to prioritize the agenda for further research. It is only through having a much better and shared understanding of the organizational issues that we can hope to meet the challenge of not 'easing the incorporation' of information and communication technologies into ever more complex organizations, but of matching changing technologies to changing organizations. From the review it becomes clear that theories and methodologies from social and business sciences are equally necessary tools to study the development, implementation and the impact of information systems in health care. Such studies will evidently be case-based and focus on a systemic description of a complex and messy world [28]. Ultimately the result of the proposed research agenda may lead to new design methods to which Berg alludes in his paper on successful sociotechnical design [29].

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# CHAPTER 2

## UNDERSTANDING IMPLEMENTATION: THE CASE OF A COMPUTERIZED PHYSICIAN ORDER ENTRY SYSTEM IN A LARGE DUTCH UNIVERSITY MEDICAL CENTER

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### Abstract

Most studies of the impact of information systems in organizations tend to see the implementation process as a 'rollout' of technology, as a technical matter removed from organizational dynamics. There is substantial agreement that the success of implementing information systems is determined by organizational factors. However, it is less clear what these factors are. We propose to characterize the introduction of an information system as a process of mutual shaping. As a result both the technology and the practice supported by the technology are transformed, and specific technical and social outcomes gradually emerge. We suggest that insights from social studies of science and technology can help to understand an implementation process. Focusing on three theoretical aspects, we argue first that the implementation process should be understood as a thoroughly social process in which both technology and practice are transformed. Second, following Orlikowski's concept of 'emergent change' we suggest that implementing a system is by its very nature unpredictable. Third, we argue that success and failure are not dichotomous and static categories, but socially negotiated judgments. Using these insights we have analyzed the implementation of a computerized physician order entry (CPOE) system in a large Dutch university medical center. During the course of our study the full implementation of CPOE was halted, but the aborted implementation exposed issues that we initially did not focus on.


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## 1. Introduction

In the traditional system life cycle approach, implementation is seen as a clearly defined phase that comes after the initiation and development phase of a system and before a system is put into actual use. Each phase has clearly defined inputs and outputs and therefore documentation and sign-offs are crucial elements of the life cycle. The phase of implementation encompasses such activities as training, conversion, acceptance testing and a post-implementation audit [1]: p. 433. In this view, implementation is understood as a 'rollout' where technology is far removed from its organizational dynamics.

Few studies have been devoted to understanding the actual processes of implementation of information systems in health care, mainly because such studies require access to hospital sites and the following of an implementation over a longer period of time. Yet it is now generally accepted that the traditional system life cycle is not very adequate to understand the process of implementation of information systems [1]. Different authors inside and outside medical informatics have sought to improve upon this understanding, and to get a better grasp on the intertwinement of technology and the organization. Kling and Scacchi have proposed the 'web of computing' in which the use of an information system is understood in terms of the larger social and technical context in which the information system is embedded [2]. Medical informatics scholars have sought to understand how information systems are diffused in organizations and the barriers to such processes. Lorenzi and Riley, for example, examined the role of leadership and change management skills to introduce new technologies [3]. In a fictitious case presentation of the introduction of a computerized physician order entry system, Ash et al. sought to identify different stakeholders and how their opinions and behavior might influence the adoption of new technology [4].

We describe findings from a longitudinal study of the implementation of a computerized physician order entry (CPOE) system in a large Dutch academic medical center. We have been in close contact with this center between 1998 and the present (January 2003). During this time, we collected data through semi-structured interviews, observations of staff meetings and document analysis. Also, we have constructed an in-depth overview of events before 1998 through interviews and documents analysis. We use this material to further enhance the emerging understanding of the implementation process. In this paper we will draw on theoretical insights from recent social studies of science and technology [5]. Contrary to more traditional views, we propose that implementation encompasses the trajectory of introducing an information system from the very first idea that such a system is needed to address perceived organizational problems to the dynamics of use in work practices [6].

The purpose of this study is to examine the three theoretical insights to understand the implementation process. First, we elaborate the claim that to understand 'implementation', one needs to focus *on the interrelation of the organizational environment and the technology.* Kling and Scacchi argue that the social context determines to a large extent how a new technology will be adopted and used by an organization [2]. They reject the idea that 'inherent' characteristics of a technology will determine specific effects in the organization, for example that increasing the speed of data flows will lead to faster and better decisions. Intent on showing the importance of social context, however, they also tend to underscore the importance of the system's technical properties. Just how an organization will react to an information system, after all, is importantly influenced (*not* determined, indeed) by the characteristics of that system. As one of us has phrased it, the introduction of information systems in health care practices is a thoroughly social process, in which both the technology and practice are transformed [5]. We have labeled this perspective the *sociotechnical* approach [7]. The term derives from the field of social studies of science and technology, where researchers aim to understand how technology is shaped as part of 'messy' networks that combine technical, social and economic elements [5].

The second aspect is the concept of emergent change and the notion of an *unpredictable outcome* of an implementation process. In the classical system life cycle each phase forms the input to the next phase. This implies that the introduction of information systems is a linear process with predictable outcomes in the form of deliverables. We will argue, however, that implementation processes are typified by contingencies, and proceed in a far from linear manner. They are part and parcel of organizational dynamics that, due to the complexity of the organizations of which we speak, cannot be foreseen, let alone be predicted [8]. In addition, the broader context in which these organizations find themselves is in a constant flux. Demographical changes, political pressure, increasing demands for quality care and new medical technologies alter the conditions in which health care is delivered. Following Orlikowski, we use the concept of 'emergent change' to get a grasp on the development of information systems in such circumstances [9]. This process of 'change' never stops: even when the implementation is 'formally' finished, users will still shape and craft the information system to fit their particular requirements or interests, often in a way unanticipated by the designers [10].

The third aspect is the concept of fit and the notion that success and failure are not dichotomous and static categories. Rather, *'success' and 'failure' are socially negotiated judgments*, which may vary depending on the moment in the implementation process and the perspective of the stakeholder focused upon. In addition, the 'success' or 'failure' of an information system lies exactly in the interaction between the system's functioning and the organization's needs and work-

| Interview no. | Interviewed person | When | Topics of interview |
|---|---|---|---|
| 1 | Project leader 1 | Jan 1999 | Goal and setup of CPOE implementation project |
| 2 | Project coordinator medical applications | Jan 1999 | Goal and setup of CPOE implementation project, envisaged nature of CPOE implementations |
| 3 | Project coordinator education and training | Feb 1999 | Education and training issues of CPOE system implementation, development of customized user manuals |
| 4 | Medical records coordinator clinical surgery and system implementation specialist | Mar 1999 | Goal and setup of CPOE system implementation project, setup and expected outcomes of pathology-gynecology pilot project |
| 5 | Project leader 2 | Mar 1999 | Goal of CPOE in medical center, setup of pilot project, collaboration with various clinical departments |
| 6 | Chief gynecologist ambulatory clinic | Mar 1999 | Goal of CPOE pilot, planning of the pilot project, nature, workflow of pathology orders, expectations about CPOE and expected outcomes of the pilot project |
| 7 | Chief pathologist | Apr 1999 | Expectations of CPOE and pilot, workflow issues in pathology |
| 8 | Pathology technician | Apr 1999 | Workflow issues of pathology, experience with pilot setup |
| 9 | IT administrator department of pathology | May 1999 | Setup of pathology pilot, general issues of experience with CPOE system implementation since beginning of project |
| 10 | IT administrator department of pathology | May 1999 | Clarifications of issues raised in first interview with respect to implementation of the CPOE system |
| 11 | Medical records coordinator clinical surgery and system implementation specialist | Jun 1999 | Review of pilot project and evaluation of CPOE system implementation project |
| 12 | Project coordinator CPOE system | Jul 1999 | Evaluation of CPOE system implementation |
| 13 | Project leader 1 | Jan 2000 | Review of aborted implementation and goals of CPOE |
| 14 | Project leader 2 | Jan 2000 | Review of aborted implementation |
| 15 | Project coordinator medical applications | Feb 2000 | Review of aborted implementation |

*Table 1 - List of interviewed persons*

Three interviews were held in prior to the implementation pilot project and the issues addressed pertained to the goals of the CPOE system implementation and the setup of the pilots. The interviews in 1999 addressed the CPOE pilot gynecology-pathology, but general issues were raised as well. The interviews in 2000 were conducted after the presentation of the external evaluation results. The first author remained in contact with the project leader and project coordinator medical applications after 2000.

ing patterns [11]. Lorenzi and Riley wrote that a "technically best" system can be brought to its knees by people who do not feel ownership and resist implementation, while a "technically mediocre" system may be extremely valued by its users [12]. Often, even apparently clear-cut technical shortcomings can be the result of poorly managed development processes [11]. We explore how the concept of *'fit'* can give meaning to a successful implementation of an information system [13]. Southon et al. introduced the concept of fit in health informatics to emphasize the importance of the organizational configuration in managing the transfer and diffusion of technology, specifically organizational strategy, structure, management processes, roles and skills [14]. Our focus is on the necessity of *actively* producing fit between work processes and information technology.

## 2. Research methodology

Qualitative research methods are very appropriate to study systems in organizational contexts. Information systems in organizations are complex technological artifacts because they are shaped by time and continuous change [15]. From 1998 the first author conducted open interviews, attended meetings and studied documents about the selection, specification and implementation of the information system, and the evaluation of the CPOE pilots.

The interviewed persons included the two project leaders and the medical and the technical coordinators of the implementation team of the CPOE system and the members of the pilot project that tested the feasibility of order entry in gynecology and pathology. In total 10 persons were interviewed and 15 interviews were conducted (see Table 1). Apart from the staff gynecologist and head of pathology all interviewed persons had various roles during the course of the implementation. Therefore they could provide us with a unique insight about the full history of the introduction of the system. The interviews lasted between one and two hours. Ongoing contacts have been maintained with a few members of the now dissolved implementation team, who are still active in informatics projects of the medical center. In addition we observed and took notes of all staff meetings of the pilot project that we followed. We observed the use of the system during the pilot project, and occasionally asked the users what they were doing. In the staff meetings we focused on how the participants were behaving and what they were saying.

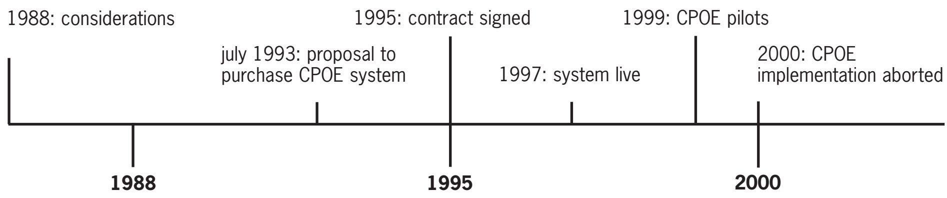


*Figure 1 - CPOE system implementation timeline. The timeline indicates key events during the implementation of the system.*

Finally, we also observed and took notes of the meetings in which the conclusions of the consultancy firm about aborting the implementation were presented. The documents pertaining to this advice and the decision making about the cessation of the implementation were also made available to us.

Notes, interviews and implementation documents were coded for occurrence of specific keywords, but generally the documents available to us were structured such that patterns could be extracted.

Permission to study the documents, interview persons and attend meetings was obtained from the steering committee of the CPOE system implementation project. The use of patient data was not envisaged and did not take place. Therefore we did not seek approval of the medical ethics committee of the medical center.

## 3. The case of the implementation of an order entry and results reporting system

### *3.1 History of the implementation*

Contrary to other Dutch university medical centers, a large 953-bed university medical center in the east of the country has always developed its own information systems. In 1988, the hospital concluded that its hospital information system was becoming obsolete and decided that it would rather buy an off-the-shelf product than build a new one again (see figure 1 for implementation timeline). As a key feature, the new system would have to be focused on the core business of the hospital: supporting clinical work (rather than only clerical work). A small group of senior staff from nursing, medicine, clinical laboratories and information systems departments, the initiators, set out to identify the needs of the hospital and scout for information systems available, especially in the USA.

The computing infrastructure of the medical center consisted of two IBM mainframe computers under the operating system MVS/XA and the network protocol SNA through which a host of other systems and terminals were connected. On one mainframe resided the information systems in use; the other was used for back up, and development and testing purposes. The medical center had been using IBM systems since the late sixties.

The university hospital clinical registration system (UZIS) was home grown, while the financial, clerical and personnel software packages were commercially acquired. UZIS allowed for requesting diagnostic and therapeutic treatments, registering diagnostic and therapeutic interventions and ordering laboratory tests. In a way, it was a very primitive order entry system.

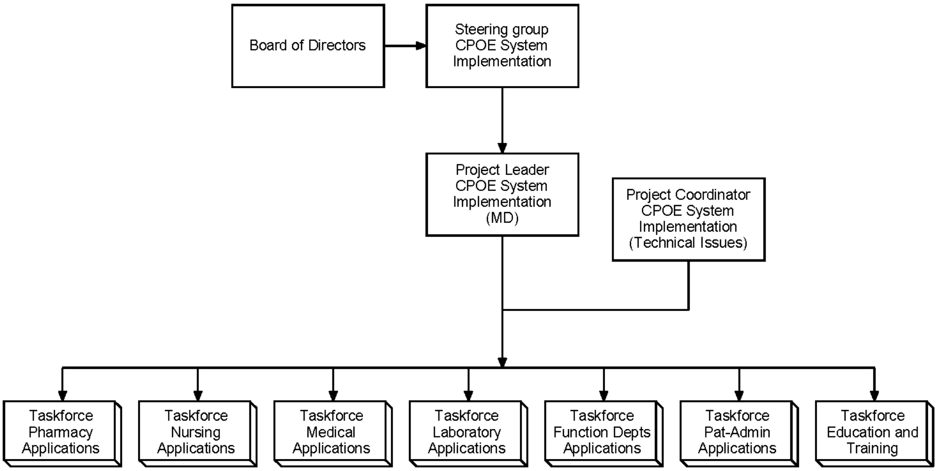


*Figure 2 - The structure of the CPOE system implementation team. The coordinators of each taskforce and the project leader formed the implementation team. The project leader was a physician who spent about half time on the project and was for the other part still active in medicine. The project coordinator, a senior member of the IT department, was responsible for all issues technical of the implementation and coordinated the members of the implementation team on a day-to-day basis. Each taskforce was responsible for a particular application domain. The taskforce 'Function Departments' encompasses departments, such as radiology, nuclear medicine, pathology, and vascular ultrasound imaging. The taskforce for pharmacy applications was planned to become active in a later stage. The director of IT was member of the Steering Group.*

The existing computing infrastructure and cost considerations constrained the choice of a new information system. An internal report of 1990 described three systems available for the Dutch market, of which the TDS7000 system of the TDS Healthcare Systems Corporation[1] was favored. The medical center had always built its own clinical registration system on the existing IBM mainframe infrastructure. It therefore maintained a large development and support group of about 100 staff. Yet the center felt that building and maintaining a complete

[1] Eclipsys Corporation has acquired TDS Healthcare Systems Corporation. The TDS7000 hospital information system is now known as the E7000 system. Eclipsys ceased selling the system but the installed base is still considerably large. The authors would like to emphasize that the system is taken as an example to address implementation issues, none of which are intended to be portrayed as product specific. We shall therefore use the term "CPOE system," or "the system."

clinical system on its own would be a risky (and potentially very expensive) strategy. Also, changing the technical infrastructure would be costly. The acquisition of the hospital information system that was used by all other university medical centers in the Netherlands and that ran on a different platform was therefore never seriously considered.

The medical center wanted to move towards more clinically oriented systems. All three systems under consideration supported order entry and results reporting. The decision to move towards the TDS7000 system was motivated by site visits in the USA convincing the participants (including key future users) that the system was the best choice: it had advanced functionalities, its configuration was highly flexible, and it would be feasible to connect to systems already in use because of the network and data communication protocols. With this system, the medical center thought, it would become the leading center in patient care information technology, moving far beyond the other university medical centers in the country.

In July 1993, the group proposed to purchase the system, which was primarily a computerized order entry and results reporting system for physicians. The system had been developed in the late sixties and was the first system specifically designed to have the work of health care professionals as its core orientation rather than being oriented to the support of clerical and financial activities [16], p. 293-297. The advantages listed were less paperwork, more complete orders, fewer transcription errors and faster availability of results. Indeed, later studies showed that CPOE reduces medication errors and improves patient outcomes [17]. It was expected that reductions of clerical staff could be achieved because of the reduction in paper work and a more efficient user interface. However, the hospital community was assured that the nature of their work would not seriously change and that there would be no job redundancies. In 1995, after a number of site visits (in the USA and UK) and in-house consultations of medical and nursing staff and representatives of the employees, the board of directors signed a contract with the vendor to deliver the system and the accompanying support and implementation procedures. The decision was made to implement and activate the registration functionality first so that UZIS could be phased out as soon as possible, and to implement the CPOE functionality after a limited number of pilots. Between 1995 and 1997 work focused on the configuration of the system and training the trainers. Training of all prospective clerical users, including the super users, started about six months before the system became operational. Computer based training facilities were made available for classroom and individual 'walk-in' training. Each prospective user had to pass a computer-based exam before he or she would be issued a password and authorized to use the system. Freeing time for training and education proved to be difficult for busy clerks and caused an extension of the originally planned training period that was to end in the summer of 1997. The hospital community was informed about the progress of implementation through articles in the hospital news magazine and special newsletters. These articles were of a human-interest nature since they focused primarily on the personal experiences of individuals in the project. The newsletters carried more factual information, such as descriptions of the system and its parts, the implementation plan, the progress, training and software releases.

The system went live on December 1, 1997. At that moment only the clerical functions of patient admission, medical procedures registration and patient scheduling became active hospital wide. During 1998 and 1999 many corrections and improvements were made to meet the needs of the users and counter serious problems (see further). 1999 also saw the start of the next phase of the introduction of order entry and results reporting functionality. A few small-scale pilots were conducted to assess the effects and feasibility of fully implementing this functionality. Yet, as we shall see in more detail later, from the summer of 1999 physician resistance against the CPOE system built up significantly. The board of the specialist staff (medisch stafconvent[2]) requested an external review of the system. In October 1999 the hospital board hired a consultancy firm to review the system and the project management structure and to make recommendations for the continuation of the project. In February 2000 the consultancy firm advised the board to discontinue the implementation of the system, which was graphically depicted as a Trabant[3] car with square wheels (see further). In December 2000 the board decided to freeze further deployment of the system and not to implement CPOE. It only would allow system modifications to maintain current functionality for the hospital, minimizing the damage, as it were, until a new system would have been selected and implemented.

### *3.2 The project team*

A project team (see figure 2) was responsible for the implementation of the system. This team reported to a steering group, which consisted of key individuals representing the medical departments and the hospital board. The steering group made major decisions about the implementation process, including involvement of clinical departments and the allocation of funding. A medical specialist headed the project team. His main tasks were to manage the project and to ensure the ties with the medical professionals and other stakeholders

[2] The 'medisch stafconvent' is the formal gathering of all tenured medical staff of a Dutch university hospital. The stafconvent advises the hospital board in all matters medical. Some decisions cannot be made without its consent. The board is elected by the membership.

[3] Trabant was a car of East German make that was proverbial for the fully outdated technology of the then communist government.

within the hospital. His position was part-time in order to allow him to continue medical practice. A project coordinator, a senior staff member of the IT department was responsible for the day-to-day management of the project team and all matters technical. The other members of the team came from the information technology department. The latter primarily focused on 'technical' issues such the development of specifications, designing databases, creating a technical infrastructure, designing screens and educating future users. Each member, also, addressed a specific domain of applications of the system. Each main domain—medicine, nursing laboratory, radiology, pharmacy, patient registration and scheduling—had its own taskforce consisting of members of clinical departments and technical staff. These taskforces decided on the way the system would be used and which functionalities would be implemented within their domains.

In the beginning the local project team was mirrored by a team of the vendor as part of their implementation procedures. This was later abandoned because the implementation took more time and effort then expected, and the costs were becoming prohibitive for the hospital. According to the same procedures, key contact persons were appointed at all clinical, ambulatory clinical and ancillary departments. The original list numbered close to 150 names. The key contact people were usually physicians, nurses, clerical personnel or technicians

**Key figures of the university medical center for the year 2002**

| | |
|---|---|
| Ambulatory clinical department visits | 381,011 |
| Clinical admissions | 24,494 |
| One day therapeutic treatments | 15,410 |
| Bed occupancy rate | 60% |
| Beds | 953 |
| Staff | 8,153 |
| Fulltime equivalents | 5,548 |

*Table 2 - Key figures of the university medical center for the year 2002. Ambulatory clinical departments are an intrinsic part of the Dutch hospital system and are linked to the equivalent clinical departments. Staff physicians and residents see their patients at both places. In the Dutch system patients need to be referred by their family physician to see a medical specialist. A medical specialist will usually see the patient first in the ambulatory clinic and then decide what further action will be needed, including a clinical admission. Therefore ambulatory clinical departments process a high number of patients. The number of single day treatments is a significant compared with the number of clinical admissions. The high number of staff is indicative of the high load of training requirements.*

who were supposed to be familiar with work procedures in their departments. However, this approach was also abandoned because the number of people involved was too large to manage properly and it proved to be difficult for these contact people to produce useful information and specifications for the implementation staff. The project team relied most on the expertise of the members of the different taskforces.

### *3.3 Computerized Physician Order Entry*

The core functionality of the system was CPOE around which the future development of the electronic patient record would be shaped. Our study focused initially on this point. The implementers expected that all physicians would use this application. The people involved in the gynecology-pathology CPOE pilot held the same view. Writing orders, after all, was the professional responsibility of the physician and was not to be delegated to nursing or clerks. User codes, passwords and electronic authentication would ensure that only physicians could enter orders and that any misuse of the system could be detected through logon trails. However, this core functionality was never implemented organization wide, and could not be studied in full.

## 4. Analysis

### *4.1 The sociotechnical reality: the intertwinement of organizational environment and technology*

Existing technologies and organizational arrangements are important factors that determine the introduction of new technologies, such as the introduction of CPOE. In the case of the university medical center the organizational considerations determined the choice of the system could be summarized as follows.

- The existing IBM technological infrastructure narrowed the choice. The technology itself did not dictate the choice but the associated organizational arrangements did. For instance, a large body of IT-staff over a long period of time had gained expertise to develop and support the IBM infrastructure including the mainframes and the network. It was simply too costly to retrain them for a new computing infrastructure or to replace them.
- Another factor was the fact that investments had been made in non-clinical IBM mainframe applications, such as personnel and billing systems that had to be connected to the new clinical application. Again it would be a destruction of capital investments and human resources if these systems had to be replaced.

The system had of course to be adapted to the Dutch situation. The most visible adaptation was the translation of the screens into Dutch. But the more sub-

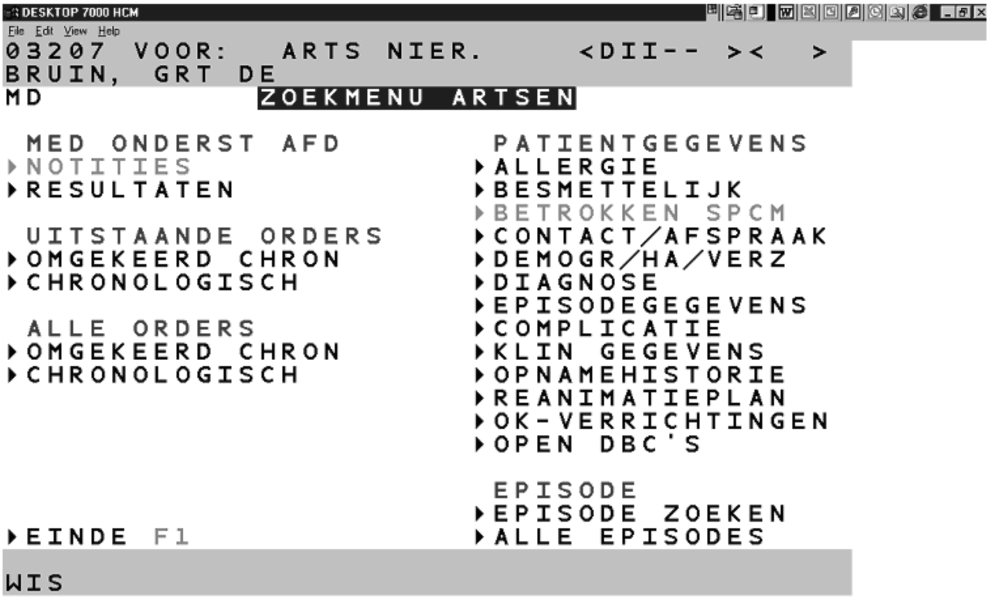


*Figure 3 - Dutch translation of a TDS7000 system screen. This menu screen allows doctors to see standing orders and patient data. Under the heading 'Patientgegevens' (patient data) the last arrow is a reference to the DRG like classification scheme (DBC's) that will become mandatory in Dutch hospitals as of January 1, 2004. Note the coarseness of the system emulation compared with the finesse of the Windows environment (see Windows task bar).*

tle part was the translation of the clerical workflows into pathways within the system. This led to an explosion of the number of screens to reduce the rigidity of the implied workflow. Sometimes this adaptation was difficult to achieve. The system was conceived to be used within the American hospital system, which is primarily oriented to its inpatient functions. The CPOE implementation in El Camino Hospital is a good example of that approach [18]. It proved to be more difficult to adapt the system to the Dutch situation, where medical specialist diagnostic assessment and therapy takes place in ambulatory settings ('polikliniek', ambulatory clinical department or ambulatory clinic). The ambulatory clinics process a high number of patients per day and form an integral part of the medical center (see table 2). With a referral letter from his family physician a patient usually sees a medical specialist first in the ambulatory clinic. The medical specialist may then decide to admit the patient clinically, or continue treatment in an ambulatory mode. Also after a clinical discharge a medical specialist would see his patient in the ambulatory clinic for follow-up treatments or check-ups. We examine the consequences of that later in this paper.

The screens of the CPOE system were translated into Dutch as figure 3 shows. The mainframe screens were emulated in a Microsoft Windows environment. Data could be entered with the keyboard or with the help of a mouse and clicking on selected fields on the screen, a key characteristic of the system. The mouse movements were very coarse. The interface was originally conceived for terminal interaction with a light pen. For adequate user interaction the screen could hold maximally 24 x 40 characters.

The implementers of the system assumed that the introduction would not significantly affect the organization for two reasons. First, the introduction of CPOE would build on a functionality that already was agreed upon in 1983, and that was, though very limited and primitively, implemented in UZIS. The functionality was expected to remain basically the same. Second, the existing IBM infrastructure would remain familiar to most IT staff, while the Windows emulation would make use easier. The implementation focused at first at translating the clerical procedures of UZIS into the new system. In a later stage, the functionality of real-time physician order entry and results reporting would be added.

In reality the implementation had a drastic impact on the organization. Soon after the implementation, clerical users found that retrieving and entering patient data took much more time because each screen would only allow them to handle a limited amount of data. For most tasks, many more screens now had to be worked through. Also, when making (typing) errors they had to go back in the pathway and redo a part of the transaction, or even the whole transaction. Furthermore they discovered that data they held to be essential vanished after a few screens. In the old system, some data such as the patient ID-number would remain in view to help navigation through the system.

All this caused a severe slow down of work processes, which created chaos at the ambulatory clinical department desks: long lines of (often angry) patients waiting to be helped, frustrated physicians, and verbally assaulted secretaries.

> "Are you so stupid that you can't handle a computer?"
> [*Patient, ambulatory clinic*]

The problem could only be remedied by increasing the clerical staffing of the ambulatory clinical departments in order to handle the patient load. This was quite contrary to the expectation that the introduction of the new system would save on personnel, as was projected in the proposal.

The problems that the users encountered with the system showed that the registration work processes were closely interrelated with UZIS, the old system.

The screen of that system would hold the patient number always on the top line. The users were very proficient with use of command and function keys to interact with the system. A telling example was the following. The laboratory system could not be connected to the system after the 'big bang.' UZIS remained functional to allow users to see the data of the laboratory information system. Users of the system would also access UZIS at a terminal next to the PC and use the patient name and number, visible on that system, to navigate through their own.

The recurrent problems also changed the attitude of those physicians who were at first champions of the system. When they saw that the workload of the clerks had increased and were confronted with the practical consequences of the system in use, they turned into opponents of the system. They started to emphasize that it was not their task or interest to spend so much time behind a computer.

> "The system requires a doctor to send electronic notes. Doctors don't send notes. They have other people doing that for them."
> [*Physician, former project leader CPOE implementation*]

Weiner et al have reported a similar response of physicians towards CPOE [19]. In economic terms, CPOE envisages the most highly trained professionals with the greatest opportunity costs to be placed in the data-entry role [20]. Given the legal distribution of responsibilities, and the expectation that work procedures would be streamlined, the designers in the medical center had embraced this principle. The professionals, however, now started to rally against this idea because it was clear to them that the system would cost them time. What was much less clear to them was what benefit it would bring and how it would fit in their work practices.

Another problem occurred at departments where patients would undergo diagnostic or therapeutic treatments. The budgeting of these departments depended on the number of patients treated. When after some months the figures requested from the information systems department turned out to be wrong, it took a few months to find the cause. This endangered their proper enumeration, which caused uproar among the medical specialists involved. (In fact, it turned out that the main problems were due primarily to poor instructions on how to enter patient information correctly into the system). Other small issues further hurt the acceptance of the system, such as a problem with clinical trial patients who erroneously received bills for their experimental treatments.

Our findings emphasize the intertwinement of organizational and technical elements in information technology. The combination of technical considerations (the pre-existing IBM infrastructure) and organizational considerations such as 'cost containment', 'being clinically oriented' and 'being a leading medical center' together led to the choice for the CPOE system. The system, subsequently, was translated into Dutch, and tinkered with to be able to support the typical Dutch 'ambulatory clinic' emphasis in hospital work. When put to work in actual practice, the technical features of the system felt restrictive and cumbersome to the users—especially in a time that more and more people had become adjusted to graphical user interfaces. This restrictive and cumbersome 'feel', however, was not just a technological issue: the screens could have been configured differently (e.g. more easy to use in admitting a patient), but they were not. Also, organizational routines could have been altered to fit the system better, but that was also not tried. Finally, the choice to have the physician in the data entry role was not a technological necessity: it was an organizational, largely unquestioned, implementation choice.

Understanding the implementation of an information technology, therefore, requires a simultaneous orientation towards both social and technical aspects. Likewise, the account illustrates how it is useless to attempt to determine whether the experienced problems were ultimately 'technical' or 'human'. Technical design finds its roots in the organizational conditions and arrangements and organizational conditions are changed as a result of technical design, as the example of the clerical users demonstrates.

### *4.2 The unpredictable outcome of implementation processes: emergent change*

In 1999, a few pilots were conducted to assess the feasibility of the order entry and results reporting functionality of the system. The main objectives of the pilots were to understand how and which work practices would be influenced by the system, to identify program errors and to establish the conditions and to plan for a hospital wide rollout. The conditions were classified in three categories, which were the description of work processes and possible adaptation of the system's functionality, the technical infrastructure, and the level of support and training for users. It was thought that if the conditions in these categories were judged to be adequately met, then the order entry functionality could be activated.

The departments of the hospital were selected according to a judgment about how well work processes were formalized. The department of radiology and nuclear medicine and the department of pathology were considered good candidates for starting pilots since both departments were thought to have well formalized work routines that would require little adaptation. The clinical department and ambulatory clinical departments were selected through the informal network of the project leader and other team members and at the suggestions of the radiology and pathology departments. There was little preplanning of the pilots. For example, it was agreed that physician order entry would be implemented as a pilot between the departments of gynecology and pathology because during examinations physicians would usually take tissue specimens and send them to pathology. The number of orders was expected to be sufficient to make a valid assessment of the feasibility of order entry. A plan was made detailing who would be involved in the project. Only a few days before the start of the pilot the technical staff discovered that the expected refurbishment of the operating theater was cancelled and that it was impossible to install a PC because the whole theater would have to be rewired to comply with electrical safety regulations. The pilot then moved to the ambulatory gynecology clinical department and only one doctor was involved. A PC was activated close to the nursing station and a printer was installed for printing labels. Actually, the participants including the pathologists, the pathology technicians and the attending gynecologist and nurses evaluated the outcomes of this pilot very positively.

The connection of the CPOE system with the laboratory information systems of the hospital was considered crucial for lab ordering. As in most modern hospital laboratories, the processing of samples and analysis and collection of data is to a large extent automated. The selection of a new laboratory information system in the department of clinical chemistry turned out to be very problematic and was only resolved well after the decision to abort CPOE implementation. No connection was made with the new system and UZIS was still used to see the data on the old laboratory system. The selection process was not a responsibility of the implementation team; it belonged to the laboratory people who did not want to be involved with the project because they thought that they had already enough problems of their own. It crucially affected the planned implementation.

The examples of the selection process of the pilots and the laboratory information system shows that it was fraught with uncertainty because it was dependent on the willingness of individuals and departments to participate and on the local contingencies. In a hospital there is no central line of command that can align departments and projects. The process contributed to the overall unpredictability of the outcomes of the pilots.

Time influenced the implementation process. Because several years passed after the decision to implement a new system users got acquainted with Windows based personal computers. The interface became 'stone age' in appearance.

> *"The characters look like Braille"*
> [Nurse, dermatology clinic]

Especially due to the pressure from the physicians, the Board of Directors started to shift their position with regard to the CPOE system. The board did not move towards 'owning' the system but looked for arguments to halt the implementation. Finally, by having an external review they effectively blamed factors outside of their influence, such as the aged character of the system in the context of rapid developing Windows based PC-systems.

The end-result was a 'lock-in' situation. The full-blown implementation of the system was aborted, but the system was not put out of use. Nobody was happy with the system, but on the other hand it was clear that for the time being no alternative was available. The system is still in use as a patient registration system, and in due time will be replaced by a new system. Work is now focused on the development of graphical workstations that allow health care professionals to see patient data in a clinically meaningful way.

Designers and implementers devote much effort to controlling the implementation process. Pilots in this perspective are meant to identify shortcomings of the system that can be remedied before a full-blown implementation. The scaling down of the gynecology pilot was not anticipated, as it was the result of contingencies that they could not know. The implementation team did also not realize when the pilots became futile. They did not recognize how adverse experiences with the patient registration portion of the system had negatively affected a major stakeholder group. In the dynamics of implementing the system the above-mentioned changes were not anticipated and certainly not planned for. Planning occurred as a response to new arising situations, as the gynecology-pathology pilot showed. The focus on systems implementation as technical strategy allowed different stakeholders to develop their own agenda, as circumstances would dictate. Changes only emerged as a coming together of contingent events and decisions made on an ad hoc basis. As Orlikowski puts it: "emergent change is the realization of a new pattern of organizing in the absence of explicit, a priori intentions [9]." Therefore we would characterize the implementation of an information system in a complex organization as 'emergent change.'

### *4.3 'Success' or 'failure': producing 'fit'*

The implementation of an information system in clinical practice is not a linear process with a defined starting point, clearly delineated goals and readily identifiable stages. By most accounts, the implementation of the system was a failure (although the system is still in place). Looking back, the functionality of order entry and results reporting which constituted the core of the system was never activated. But it would be too simple to argue that this failure could have been predicted at the beginning of the project. Similarly, it would be too simple to say that a simple checklist with critical success- and failure factors could have prevented the problems. The outcome was rather the result of a series of events and contingencies that were not planned for or whose impact was not anticipated. Decisions that looked reasonable when made can thus become constraining and clearly 'wrong' in retrospect. Each step in the process of implementation leads to new and partially unpredictable outcomes that have to be judged in the context of the new situation. In the checklist, the box 'appropriate technology' would have been ticked at the time the procurement decision was made: the mainframe technology appeared to be highly problematic only later. At the time of the decision, the choice for the IBM mainframe environment made perfect sense: infrastructures based on PC-technology for large organizations were far from mature up to the middle of the nineties. One may conclude that long lead times for implementation are questionable because objectives, goals and context (organizational and technical) can change drastically over time—yet it is hard to imagine how such expensive and complex implementation processes could reduce their lead time sufficiently. In complex organizations large-scale implementations are observed to take a long time. Such long times are even deemed to be necessary for the mutual learning process to develop and implement information systems [20, 21].

There is, then, no simple formula for success or failure. The complexity of the sociotechnical networks, and the inherent unpredictability of IS implementation within complex organizations, is simply too great [11]. In addition, what *counts* as success or failure is not clear-cut, but the outcome of a social negotiation. Many different definitions of 'success' or 'failure' can and are employed by the involved actors [11]. In this case study, the proposal to introduce the CPOE system very much focused on savings. Savings could be found in fewer budgets spent on system development and maintenance and reducing the number of clerical staff. The benefits of medical order entry and results reporting were phrased in technical terms of better readable and more complete orders, but the consequences for medical work were not highlighted. Some studies and reports in the public press have shown that cost benefits of strategic IT in health care and the services industry in general were not achieved [22]. In the discussion about medication errors physicians do not see themselves as part of the problem [23]. Other professionals in the loop of ordering medication often correct potential errors so that the ordering physician is not confronted with the potential negative outcome of his action [24]. In a survey of hospitals that have implemented order entry and results reporting systems, Ash et al. found that in only 15% of these hospitals physicians were using the system [25]. The remark of one of the leading physicians in the CPOE system implementation project that physicians don't send electronic notes is a telling example.

From the case study it became apparent that the system did not fit well with registration work practices. In a study about evaluation of medical informatics applications, Kaplan made a plea to employ evaluation methodologies based on social interactionist theories [26]. In this paper she suggested that 'fit' is a key factor for the successful implementation of information systems in health care. 'Fit' has various dimensions such as compatibility of the system with the workflow, with the level of expertise of the users, with the belief system of the user or the organization, and so forth. We agree with Kaplan that fit with work processes constitutes an important explanation for success. However, we find that whether 'fit' exists or not is not due to the technology introduced and the practice in which it is to be used. Rather, this 'fit' *has to be actively produced:* the technology and the practice have to be *made* to fit. An information system has to be adapted to the work practices of the user, but users will have to change their practices as well as a result of the opportunities and constraints of the technology. To achieve this fit, first of all, requires a thorough understanding of the work practices. Yet an analysis of work practices should not only include an analysis of what people do, but also how they might do it *better* [27]. Often, a proper understanding of a system's functionality can point into the direction of such improvements. In this case, for example, it was a moot point that the hospital did not attempt to restructure work routines so that an order entry system would be able to articulate with the practice much better [6]. An order entry system becomes truly useful, even for doctors, when standardized care paths and protocollized order sets are made part and parcel of working routines. A deeper understanding of clerical work practices, also, might have led to their reorganization and perhaps could have prevented the increase in the number of clerks. In the current example, since 'organizational change' was not planned, measures to remedy organizational impacts were now mainly defensive. Alternatively, proper IT implementation should *always* be seen as a process of organizational change, and should thus *always* be oriented towards a redesign of—in this case—professional working patterns [28].

## 5. Conclusion

In the case study of the implementation of a CPOE system in a large university medical center we have sought to further our understanding of the process of information systems implementation. We argue, first, that the introduction of the order entry and results reporting system can only be properly understood if we consider the social and technical aspects of the story as highly interrelated. 'Implementation' is not a purely 'social' process; nor is it determined by or reducible to 'technical' issues. It is always and irreducibly both. This makes the task complex for the analyst, since he or she should be able to dive deeply in both the organizational dynamics and the technical details of an implementation account. In addition, it points at the difficulty of *managing* an implementation: there as well the challenge of 'bridging' and integrating the organizational dynamics with the technical (im)possibilities has to be met head-on [29].

We argue furthermore that the implementation process is highly unpredictable. At the time of the decision to implement the system no one could foresee that later experience with PC-windows technology would influence the attitude of users. Despite the fact that the implementation of the system has been 'frozen' continuous changes are made to incorporate new requirements such as the coming of a DRG-like financing scheme in Dutch hospitals (see figure 3). We saw that the implementation process was influenced by contingencies that were not expected and certainly not planned for. Some were small, as for example the move of the gynecology order entry pilot from the inpatient clinic to the ambulatory clinic. The 'feel' of an interface becoming obsolete and the changing position of the medical staff were major changes that had major impact on the acceptance of the system. Unanticipated and unplanned changes are part and parcel of the implementation process and can often manifest themselves in hindsight. Emergent change is key characteristic of implementing information systems in complex organizations.

We conclude that there is no simple formula for success because of the complexity of the sociotechnical networks and the inherent unpredictability of IS implementation within complex organizations such as the university medical center. Failure of the implementation could not be predicted at the beginning. But it became apparent that the information system did not fit well with work practices. In our view 'fit' can be seen as a key factor for the successful implementation of information systems. But fit is not a property that relates to the nature of technology or work practices; it has to be actively produced. Just analyzing work practices to discover how technology might be implemented is not sufficient. Both technology and work practices have to be changed to implement an information system successfully.

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# CHAPTER 3

## COMPARING THE IMPLEMENTATION OF COMPUTERIZED PHYSICIAN ORDER ENTRY IN TWO DUTCH HOSPITALS: SAME SYSTEMS, DIFFERENT OUTCOMES

Jos Aarts, Marc Berg


### Summary

*Objectives*

To compare the outcome of the implementation of computerized physician order entry (CPOE) systems in two Dutch hospitals. *Methods*: Qualitative research methods, including interviews in both hospitals, observations of system in use, observations of staff meetings and document analysis, were used to understand the implementation of CPOE. The transcribed texts and implementation documents were analyzed for relevant concepts. The transcripts and field notes were analyzed using a heuristic success and failure model with medical work as the primary focus.

*Results*

Occasions that determined the outcome of the implementation were classified according to factors that may influence the success or failure of implementing systems.

*Conclusions*

The themes and patterns that emerged from the data helped validate the concept of medical work as the primary focus of our analysis model; in addition the concept of a support base necessary to accept changes in medical work that result from introducing CPOE may help to understand the different implementation outcomes.


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## 1. Introduction

Computerized physician order entry (CPOE) systems have been implemented and used in hospitals for over thirty years. In 1971 El Camino Hospital, a 440-bed community hospital in Mountain View (California) implemented CPOE and the system has been in constant use ever since. Evaluation of the system showed savings in terms of the turnaround times of medical orders [1]. Despite the implementation in some prominent hospitals the adoption of CPOE in US hospitals has not been widespread as was evidenced by the 1998 survey of Ash et al [2]. CPOE caught attention again after two reports by the Committee on Quality on Health Care in America on medical errors and improvement of the quality of the health system suggested that the wider introduction of CPOE would reduce the number of medical errors significantly and that therefore CPOE would improve the quality of care and patient outcomes [3, 4]. Indeed, studies such as by Overhage and Bates have shown that CPOE can reduce medical errors and adverse drug events and improve patient outcomes [5-7].

The implementation of CPOE systems however, has been fraught with problems. Massaro described how residents in the University of Virginia Medical Center opposed the implementation of CPOE [8]. Although they felt that the system cost them too much time, its use was mandatory. Ash et al. found that in only 15% of the hospitals that had implemented CPOE physicians were using it [2]. Ash et al. later concluded from a cross-site study of CPOE in hospitals that implementation strategies for CPOE should be designed for its complex nature [9]. Despite the indication of positive outcomes of CPOE, the call of the Leapfrog Group—representing Fortune 500 companies providing health benefits—to implement CPOE and legislation of the State of California requiring implementation by January 1, 2005, few hospitals have acted upon it [10]. In a recent survey Ash showed that even less than 10% of US hospitals have implemented CPOE, a figure even lower than the 1998 survey [11]. In addition there is evidence that implementing CPOE while reducing errors of prescription legibility and completeness may induce new errors [12]. From these studies one may conclude that the implementation of CPOE in clinical environments is problematic and that easy solutions are not readily available.

The introduction of CPOE is not a problem unique to the United States. We have studied the implementation of CPOE in two Dutch hospitals over a period of ten years. The implementation of CPOE in one hospital was aborted and in the other hospital only clerks and nurses are using it. We have sought to identify the factors that would explain the differences in the outcomes by focusing on medical work practices and interpreting our findings using the sociotechnical approach, which addresses the interrelatedness of technical and social aspects of a work practice [13].

## 2. Background

Scholars have sought to understand the nature of success and failure of implementing information systems for about thirty years [14]. The study of IS failures focused initially on technical system properties because building the right system was seen as problematic. During the 1980s the focus shifted towards the human-computer interface, which was seen to be poorly designed. Only recently more empirically grounded, organizationally focused explorations by which IS had failed became the focus of research [15-17]. Building upon sociological traditions that emphasize the interactions between people and between people and their (technical) environments Sauer developed an IS failure model [18, 19]. Sauer's model portrays the development of information systems as an innovation process based on three components: the project organization, the information system and its supporters. Each of the components is arranged in a triangle of dependencies in an organizational environment. The information system requires the efforts and expertise of the project organization to sustain it; the project organization is heavily dependent on the provision of support in the form of material resources and help in dealing with contingencies; supporters require the benefits from IS. In his view information systems can have flaws that cannot yet be described as failures. Systems can be delivered, at increased costs, with inadequate functionality and may be largely unused. So long as the project organization can command the resources and power to sustain its system, it will not be counted a failure because it serves some organizational purposes [18], p. 30. Figure 1 shows this triangle of dependencies.

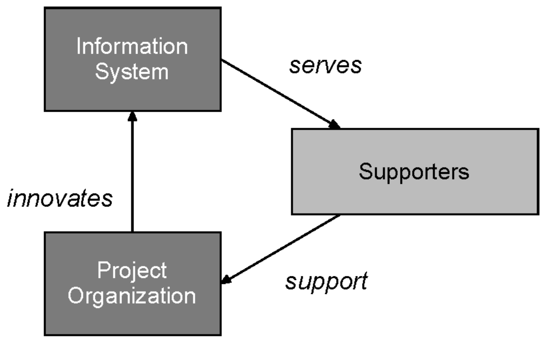


*Figure 1 - Triangle of dependencies. Sauer is intent on the role of a project organization to develop, operate and or maintain an information system. The supporters representing different stakeholders and resources provide support for a project organization. An information system is supposed to serve its supporters and their interests. The source of innovation in this model rests with the project organization (adapted from [18]).*

## 3. A SUCCESS AND FAILURE MODEL BASED ON DEPENDENCIES

We propose a heuristic model that, while preserving his concept of interdependencies refines Sauer's work in several ways. Sauer, first of all, puts the users in the role of supporters, while we suggest emphasizing their work as it is supported by the system. In doing so we are able to examine how work practices may change when an information system is put in place and how clinicians, whose work practices will change, relate to the system. In hospitals often a project organization is not well identified; assumptions about the nature of project organizations that may be valid in a corporate environment cannot be taken for granted in health care [20]. Even in the case that a project organization has a clear mandate of top management, it still may need to negotiate decisions with the medical profession before they can take effect. Moreover, a project organization may disappear, while potentially problems of implementing the system successfully may remain unresolved. We consider a project organization part of the hospital organization. Often organizational arrangements, for example a steering group, are in place to ensure its connection to regular entities of a hospital, such as clinical departments, an IT department and a board of directors.

Furthermore Sauer is very intent on the nature of the technology and not so much on the nature of the work it supports. We agree that innovation must occur when an information system is implemented. But Sauer's model tends to ignore the idea that innovation is part of work practices by assigning the driving force for innovation to the project organization.

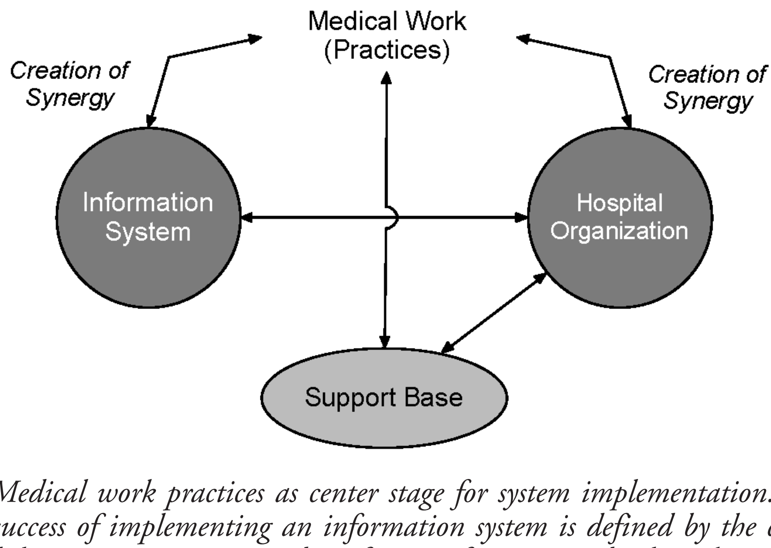


*Figure 2 - Medical work practices as center stage for system implementation. The success of implementing an information system is defined by the capability to create a support base for transforming medical work practices induced by the IT system.*

We believe that medical work practices take center stage when analyzing the outcomes of CPOE implementation (see figure 2). Users talking about an information system tend to focus on the effect upon their work. Changing work practices needs a support base, especially in health care where professional autonomy is important [21]. We define a support base as a group of persons accepting a change of work practices caused by introducing an information system. As seen later, a support base may not be equal to the information system's target group: change may not happen when a support base is lacking.

In order to implement a CPOE system successfully, synergy needs to be created between the technology and the medical work practices to bridge the requirements of the work situation and the tool's functionality [22]. Because an information system cannot be separated from a hospital organization, similarly synergy needs to be created between the hospital organization and the work practices. Synergy implies interdependency. A hospital is dependent on its clinicians how they work, but medical work practices are also very dependent on the organizational arrangements within the hospital. In the case of information systems one of us has introduced the notion of fit as a *sine qua non* for synergy to emerge [22]. Synergy is a dynamic concept. All parties, or elements of the network in sociotechnical terms, need to actively adjust to one another to create synergy. The change of medical work practices as a result of the new technology needs to have a support base; otherwise the implementation may become very problematic. On the other hand the intended target group may not accept the change, but another professional group may see advantages in taking up the change and form as a new group the support base for the changing work practices. Changing work practices may also be accepted because there is no alternative. This may explain that a complete abandonment of an information system is quite rare and only occurs if there are technologic alternatives that could support medical work and for which a support base can develop. Because of our focus on medical work practices we do not make a direct connection between an information system and its support base. The support base for changing medical work practices is crucial for the acceptance of an information system.

An information system is intrinsically connected to the hospital organization. An information system reflects a major capital investment and usually organizational conditions have been created to accommodate such a technology, for example through the establishment of an IT department or the creation of a project organization. The implementation lead times of technology are quite long, and will therefore draw on the organization's resilience. Also the information system represents a history; technological infrastructures are reflective of the organization and its constituents and often cannot be replaced easily [23].

A hospital organization is about all the constituents and work practices that make medical work possible [24]. A hospital organization, or more specifically its top management may harbor expectations or ambitions about how medical work should or will change as a result of an implicit or explicit strategy or a changing external environment. Management may try to implement that change by attempting to create a synergy between the organization and medical work practices. In hospitals it is frequently the case that in the absence of a-priori intentions of the top management groups may pursue their own agenda. The success of these groups is determined by the support base for the changes in work practices they want intentionally to achieve or, very often, unintentionally may realize. Conversely, existing work practices may influence the expectations or ambitions of the hospital. For that the hospital organization also needs to have a support base.

We view support base as a dynamic concept. When changing medical work practices usually the support of physicians is needed, but when physician support is lacking other professionals may step in. They thus can create synergy between medical work practices and the information system, but in a way not anticipated or intended by the hospital organization.

Our model would give a new perspective on success or failure of information systems. We define a successful implementation of an information system as the capability to create a support base for the change of (medical) work practices induced by the system. We can talk now about the dynamics of success or failure. We argued in a previous paper that success and failure are no static categories but are socially negotiated judgments [25]. 'Negotiation' clearly has a dynamic connotation. In our view different groups negotiate through formal and informal channels what is going to happen with an information system employing implicit and explicit strategies [20]. Such a consideration allows for positions within a hospital to shift in a way unintended by, for example, the champions of a system. The dynamics of failure may point at the failure to create synergy.

## 4. Research methods

The study focuses on the understanding of the outcomes of CPOE implementation using a heuristic model and aims to identify factors that determine successful implementation. Field and documentary-historical methods best achieve this interpretive explanation generation [26]. We gained access to the hospitals through our network of contacts. The two hospitals selected were the only in the Netherlands implementing CPOE systems at the time of the beginning of the study.

We collected data through open interviews, analysis of implementation documents, observing systems in use, and attending staff meetings in both hospitals, starting in 1997 and ending in 2003. In both hospitals we interviewed project leaders, clinical members of the implementation team, staff and resident physicians, nurses and technical and clerical personnel. The interviews were transcribed and submitted to the interviewees to correct for factual errors. A total of 25 interviews were conducted. See table 1 for an overview of data acquisition methods.

We specifically examined documents pertaining to the selection and the use of the CPOE system, the outcome of pilots in both hospitals and the evaluation by an external consulting firm.

| **Data acquisition methods** | **Hospital A ([25])** | **Hospital B** |
|---|---|---|
| **Implementation documents** | Selection and recommendation documents, 1990 – 1993 | - |
| **Other documents** | Functional specifications, 1993<br>Letters, newsletters and magazine articles, 1982 – 2003 | Functional specifications, 2001 [29] |
| **Interviews** | Project leaders, project team members, users, 1999 – 2000 | Users in nursing wards, 1997 [27]<br>Head of IT, physicians, project team members, 2001 – 2002 [29] |
| **Observations** | Pilot project, 1999 | Participant observation in nursing wards, 1997 [27]<br>Observation of system in use, 2002 [29] |
| **Staff meetings** | Pilot project planning meetings and meetings discussing the decision to abort CPOE implementation | - |

*Table 1 - Qualitative Research and data acquisition methods applied in the case studies*

We also transcribed the observations of the systems in use and staff meetings. During the observation of people using the system we would occasionally ask them to explain what they were doing. In the staff meetings we focused on the behavior and discussions of the participants. Both interviews and observation transcripts were coded for relevant keywords, but generally the documents were structured so that patterns could be extracted. The methods are described more extensively in earlier publications and documents [25, 27-29].

## 5. Case presentation: the implementation of CPOE in two Dutch hospitals

The implementation of CPOE is not widespread in the Netherlands. Of the hundred acute care hospitals three hospitals have implemented and currently use a medication order entry system [30]. Two hospitals, a university medical center (hereafter hospital A) and a regional hospital (hereafter hospital B), have attempted to implement a full scale CPOE system. The hospitals chose the TDS7000 system of TDS Healthcare Systems Corporation[1] and shared their computing resources. The key figures of both hospitals are listed in table 2. The cases will be described in more detail separately.

### *5.1 Hospital A*

Hospital A is a 953-bed university medical center in which the medical school is integrated. It employs about 400 staff physicians and over 300 residents. There are about 1500 medical students, but they do not count as qualified physicians when they do their medical rotations.

In 1988 the medical center wished to replace its IBM mainframe based home-grown hospital information system with a system that would support clinical work. Considerations for the selection of the order entry system its clinical focus, the reputation of being advanced compared with other university medical centers in the country and the retention of the existing IBM infrastructure including the expertise of the IT staff. Benefits listed were easier use and more readable and complete medical orders. The hospital signed the contract in 1995 and the system went live late 1997 with only clerical applications activated such as patient admission and scheduling. From 1997 until 1999 a few pilots were conducted to assess the feasibility of medical order entry and to prepare for a hospital wide rollout. Soon it became apparent that clerical users in the ambulatory clinical departments were not happy using the system. To complete a task, such as scheduling a patient, a secretary had to page through many screens and the Windows emulation of the CPOE system was not intuitive in use (see

| | Hospital A | Hospital B |
|---|---|---|
| Ambulatory clinical department visits | 381,075 | 432,119 |
| Clinical admissions | 24,494 | 27,298 |
| Day case admissions | 15,410 | 21,777 |
| Number of beds | 953 | 1,230 |
| Staff | 7,855 | 2,773 |
| Fulltime equivalents | 5,902 | 2,007 |
| Tenured medical staff | 393 | 188 |
| Residents | 321 | 80 |
| Non-training physicians | - | 50 |

*Table 2 - Key figures of the university medical center (hospital A) and regional hospital (hospital B) for the year 2002. Ambulatory clinical departments are an intrinsic part of the Dutch hospital system and are linked to their clinical counterparts. Staff physicians and residents see their patients in both places. A medical specialist will usually see the patient first in the ambulatory clinic and then decide what further action will be needed, including a clinical admission. Therefore ambulatory clinical departments process a large number of patients. The number of patients that gets a one-day medical treatment (e.g. simple surgery) is growing saving the hospitals the costs of expensive beds. Hospital B is involved in training of medical specialists but the number of training positions is much less than in an academic medical center. Hospital B also hires physicians who not do enter into specialist training position and accommodate for variations in patient caseload. The figures show that hospital B is more focused on 'medical' production; it treats much more patients with less personnel.*

figure 3). When it became clear that these properties slowed down the users, the physicians realized that using the system would cost them much time. Through formal and informal channels the physicians mobilized enough support to halt its further deployment. The university medical center is still using the system for clerical purposes while preparing decisions about the future role of clinical IT [25].

### *5.2 Hospital B*

Hospital B is large regional 1230-bed medical center based on three locations in an urban area. The main location offers all medical services varying from routine interventions to complex procedures. The other two locations offer basic medical services. While it is not officially an academic medical center, it is involved in the training of medical students as part of an agreement with a university med-

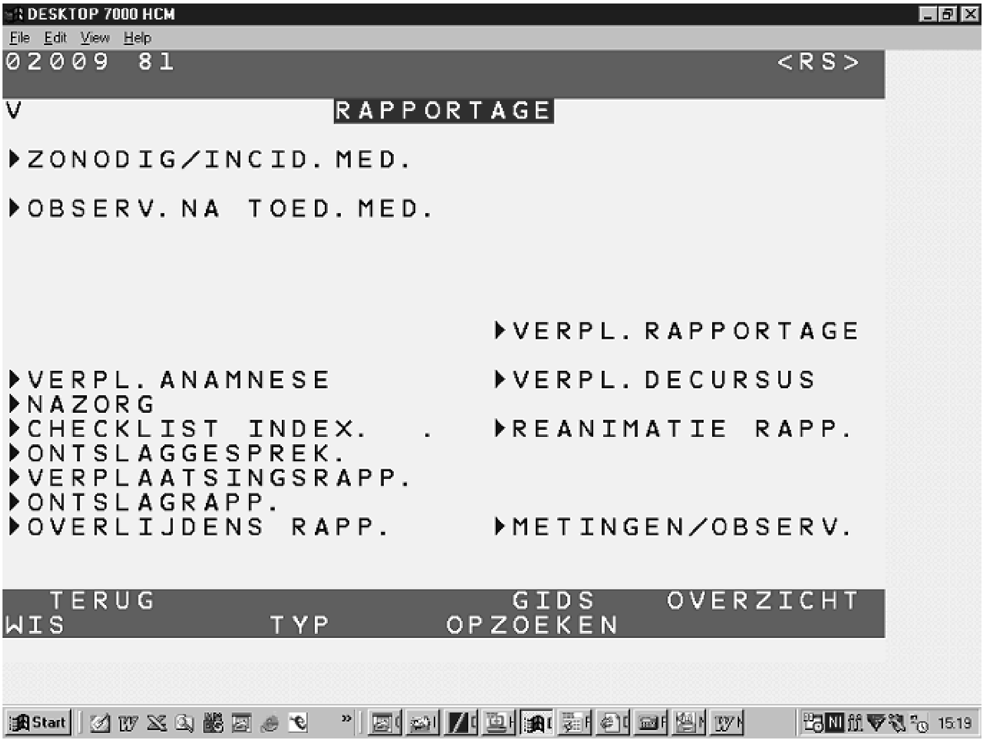


*Figure 3 - A typical screen of the CPOE system implemented in hospital A and B. Note the contrast between the coarseness of the CPOE emulation and the Windows environment. The figure represents a nursing documentation ('rapportage') screen in hospital B.*

ical center in a nearby city. The physicians are mainly self-employed and their practices are organized in medical specialty groups. The groups have a high degree of autonomy to regulate their own affairs. The hospital also provides for training of medical residents. The residents are employed by the hospital, but belong organizationally to the medical specialty groups where they are trained.

The hospital had no previous history of medical computing, and in early 1990s it felt it could move directly into implementing an information system to support medical work. Through personal contacts it was offered a deal by hospital A to use the IBM infrastructure by leasing large bandwidth communication lines. This offer would save substantially on capital investments. The two hospitals worked together to acquire the same computerized physician order entry system. The earlier implementation of the CPOE system by hospital B would provide the IT staff of hospital A with a unique opportunity to gain experience with the development and maintenance of the system. Hospital B signed the contract in 1992. The system went live in 1995 and gradually its functionality was expanded to include CPOE in all clinical departments. The system has not yet been implemented widely in the ambulatory clinical departments.

The physicians resisted the implementation of CPOE, but the secretaries, clerks and nurses appropriated the system to support their own tasks. The nurses used the system to document nursing care and entering medical orders, most of which were medication orders. In the beginning nursing use of CPOE had been made difficult by inserting authorization screens that prompted the nurses to fill in detailed information about the physician responsible for the medical orders. Later on this 'agent for' construction was simplified when it became clear that physicians would never use the system and procedures were implemented to ensure that physician would sign the orders [28]. However, medication orders proved to be problematic in this hospital. Nurses would enter orders and it was agreed that physicians would electronically authorize them or sign printed medication sheets. In reality about 60% of the medication orders were not authorized. The interviews revealed differing opinions between the physicians and pharmacy about the responsibility for medication quality. Carpenter and Gorman have reported similar findings [31].

## 6. Results: same systems, different outcomes

The case description shows how intertwined the histories of CPOE implementation in both hospitals were. The university medical center could not have moved forward if the regional hospital would not have provided the needed opportunity to get experience with the system and to convince the board to acquire it. This interdependence continues to this day. Despite these linkages the different outcomes of the implementation allows us to make a comparison and draw conclusions from it. From the documents, interviews and observations in both hospitals we identified key occasions that influenced the course of the implementation of CPOE. Using our model we examine in more detail medical work practices and the support base, the information system and the hospital organization, and how they are interdependent. The occasions are summarized in chronological order in table 3.

### *6.1 Medical work and support base*

The implementation of the CPOE system in both hospitals was aimed at physicians. The benefits of CPOE were phrased in 'technical' terms such as an improved completeness and legibility of medical orders. Since writing orders was seen as a responsibility of the medical profession the implementers expect-

| Chronology | Hospital A | Hospital B |
|---|---|---|
| **Before 1990** | The hospital had an existing computing infrastructure constraining the choice for a new CPOE system. | The hospital had only automated a few clerical applications. There was no strong computer history that could influence the choice for a particular system. |
| **1990 – 1992** | The hospital wanted to be number one in clinical computing and distinguish itself from other university medical centers. | Support of clinical work was a major driver for the selection of a new system. |
| **1990 – 1992** | | The choice for the CPOE system favored by hospital A was facilitated by the offer to use its computer infrastructure saving major investment costs. |
| **1990 – 1995** | Order entry and results reporting was already a rudimentary functionality of the old system. The implementers did not anticipate or plan for major changes when the new system would be implemented. | |
| **1992 – 1995** | The implementation of the CPOE system was initially targeted on clerks and secretaries to support their tasks of patient admission and transfer, scheduling appointments and registering treatments. | The implementation was targeted on both clerical and clinical users. |
| **1997 – 1999** | Despite expectations that work practices would not change, the new system did not fit well with current clerical work practices.<br>Clerks and secretaries in ambulatory clinical departments experienced severe slowdowns when admitting patients and scheduling appointments.<br>Responses to remedy shortcomings of the system were mainly defensive. | The clerical users changed their paper based work practices in order to make best use of the system. |
| **1995 – 2000** | Physicians never used both the old system and the new system. Clerks and secretaries, and to a lesser extent nurses, were the main users of the system. | The physicians saw no advantage in using the system, but especially nurses perceived the system as a help to their current manual medical ordering practices and nursing care documentation. At first the entering of medical orders was made difficult by inserting extra verification screens, but later this ‘agent for’ procedure was simplified. |
| **1999 – 2000** | When the physicians saw how much time the secretaries and clerks needed to use the system, they started to rally against the system | |

| | | |
|---|---|---|
| **1999** | The outcomes of the order entry pilots were not convincing to influence the position of physicians and nurses. | |
| **2000 – now** | Because of a thin support base for changing medical work practices it was not possible to implement medical order entry and no other professional group stepped in. Clerical use of the system stabilized. | The core functionalities of medical order entry and nursing documentation filled the need of nurses, secretaries and clerks and allowed them to appropriate the system. |

*Table 3 - Occasions determining the outcomes of the CPOE implementation in hospital A and B. The occasions are presented in chronological order and span the period from 1988 until 2002.*

ed that physicians would agree on the signaled problems and use the system. In hospital A the implementation was initially targeted on the clerical users to support their tasks of admitting and transferring patients, scheduling appointments and registering diagnostic and therapeutic treatments that needed to be reimbursed. In a later stage the full functionality of physician order entry would be realized. Immediately after the introduction however, the clerks and secretaries experienced severe problems in using the system. The implementers responded defensively; they tried to fix each problem and the organization added more staff to handle the increased workload for the clerical end-users. Because the old system was phased out the clerks and secretaries had no choice but to use the system. The physicians, however, observing the problematic use of the system became increasingly opposed to its further implementation. They now foresaw how CPOE would significantly change their medical work practices, tying them to a slow and cumbersome computer system. In this way they never formed a support base.

In hospital B the implementation encompassed the complete functionality including order entry and was targeted on both clerical and clinical users. Having no previous experience with computerized systems the clerks and secretaries found that the system was helpful for their clerical tasks. Yet here as well, the physicians refused to get involved because they rejected their ‘clerical’ role in entering prescriptions and work orders. They were used to writing and signing paper drug prescriptions and giving verbal and telephone orders to nurses. Their work routines were efficient and heavily facilitated by the nursing staff. In hospital B then, the nurses continued this tradition and started to enter the orders for the doctors. In the beginning the process of entering orders was made difficult for nurses by inserting extra authorization screens, but when it became clear that physicians would not change their position and enter orders themselves this process was made simpler [28]. In combination with order entry the nurses would also document nursing care. The nursing documentation was primarily used to facilitate the transfer of workshifts and print nursing care plans (figure 3). Continuing efforts by the board of directors to involve physicians in using CPOE failed, but the nurses and clerks appropriated the system to support the medical work practices much as they had been doing before. In that manner they became the support base for the system up until today.

### 6.2 Information system

How an information system will be perceived depends very much on the context. Hospital A's existing IBM hardware infrastructure constrained the choice for the new physician order entry system. The hospital had a long experience of information systems in use and inevitably the new system was judged in that perspective. The implementers assumed that emulating the terminal in a Windows environment would make easy use possible (see figure 3). In comparison to the old system the use turned to be very cumbersome. A single screen could hold limited information and therefore many screens had to be paged through in order to complete a task. Also what information and in what way it was presented on the screen was not intuitive, thereby causing loss of oversight. All this slowed down the speed of use, which was especially problematic in the ambulatory clinical departments processing large numbers of patients (see table 2). It could only be remedied by adding clerical staff. There was a poor fit between the user and the system and contributed to its rejection by the physicians.

In hospital B the users saw a clear advantage over their paper based work tasks and made the system fit in their work practices. The lack of a history of using computers could not color their judgment and therefore they were more willingly to abandon their paper based work practices. The implementation was initially limited to the clinical departments and only five years later the first attempts were made to introduce the system in the ambulatory clinical departments. Therefore the hospital did not see the slowdown of clerical work practices experienced by hospital A.

### 6.3 Hospital organization

Hospitals are highly complex organizations. They are knowledge-intensive and typified by a co-existence of a classic hierarchical structure and a juxtaposed body of semi-independent units: the medical specialists [20]. Managerial authority stops short from the autonomous professional status of physicians, whether they are employed by the hospital or more or less independently associated. This forces hospital management to negotiate with physicians about all matters medical and decisions are therefore mostly the result of compromise. Sometimes hospital management has to give in to preserve good working conditions. Only in the last decades external developments such as cost containment, the increased awareness of patient safety issues and quality improvement and patient advocacy forced physicians to align themselves with institutional goals [32, 33]. Hospitals balance also between setting goals for patient care and being mere facilitators for physicians to practice. Likewise physicians are dependent of hospital organizations for the resources they cannot afford in private practice only.

Both hospitals were ambitious in implementing information to support clinical work and viewed this as a way to distinguish themselves from other hospitals. They expected that their physicians would follow them in their ambition and underestimated the fact that medical responsibilities are not necessarily reflected in medical work practices. Both hospitals were not able to get the physicians on board. For hospital A it meant eventually the abandonment of core functionality of physician order entry and for hospital B leaving them out of the loop. The fact that hospital A could provide the computer resources to hospital B and thus allowing to save substantially on capital investments was an important factor in the decision of the latter to acquire the order entry system.

## 7. Discussion

Most recent accounts of implementing information systems focus on the user and his or her organizational environment. Here we have emphasized the centrality of medical work in health IT implementation. 'Medical work' is the core business of health care organizations; it is that what professionals are here to do and what clerks and other non-medical workers are there to support [24]. 'Medical work' is where the different resources of the hospital—its people, materials, and information—come together. Medical work is highly fluid because it geared towards treating patients, whose individual trajectories are never completely predictable [24]. This concept of medical work implies that it is not uniquely related to the profession of medicine, but other professions such as nursing or physiotherapy and even the patient may be involved.

We will now examine the interdependencies in more detail. It is obvious that medical work is dependent on and shaped by the hospital organization. Though physicians tend to see patient care as a highly individual activity separated from organizational arrangements, a hospital provides for personnel, technological and material resources that allow physicians to practice medicine. A hospital not only facilitates but also constrains. The current shortage of highly skilled ICU nurses and OR personnel clearly limits the number of patients that a physician can treat. Similarly medical work practices have become highly dependent on complex and expensive technologies and resources—including IT—that only can be shared in a hospital [34]. For example, admission and scheduling of patients, lab testing and imaging is nowadays impossible without IT and facilitates the efficient handling of a high number of patients by physicians and other health care professionals. This was an important reason that hospital A did not terminate the information system completely. A study in a Dutch academic children's hospital describes how physician drug prescribing practices can be shaped by a computerized medication order entry system that allows only to prescribe drugs listed in an electronic formulary and that the system thus might help to reduce hospital prescription costs [35].

In an ethnographic study how physicians and nurses use documents to share knowledge within and across health care settings Østerlund finds how the apparently inefficient way of taking patient histories multiple times, writing up and looking up data is determined by the nature of the work at hand such as admitting, finding a diagnosis and deciding for a therapy, coordinating care activities, and transferring the patient to an other care giver [36]. The study argues that health care records should be approached as work practice-centered and suggests that the implementation of information systems should take medical work practices as point of departure. This study supports our view that health professionals and others who work in health care organizations experience IT through their work and our choice to put medical work center stage in our model of system implementation. Related to the centrality of medical work is the question whether the formal status of a physician in a hospital influences their use of CPOE. Data from Ash et al. suggest that hospitals employing their physicians are more successful in implementing CPOE [37]. However, our findings suggest that employment status may not be a strong indicator. Although medical specialists are 'regular' employee in many European hospitals, this does not imply that their organizational role is that of a 'regular' employee. A study about medical errors suggests that the professional behavior of physicians is to a large extent determined by professional socialization during their years of residency [38]. In both hospitals the staff physicians arrived at the opinion that CPOE was not part of their professional work and the residents followed them in their stance.

Transformations in medical work practices—whether induced by IT or not—may breed enthusiasm, indifference or resistance among health care professionals. Negative reactions do not necessarily mean that a transformation will not be taken up. A professional group for whom it was not intended, but which in hindsight profited most of it may take up a change. How different professions might take up medical work practices varies from hospital to hospital and whether it is appropriate is a question not raised in this paper. The growing shortage of physicians will arguably lead to the delegation of medical work practices to other professionals and a growing role of information systems to support them. In practice already nurses are doing clinical work that formally belongs to the professional domain of medicine [39]. For example, the British government allows NHS nurses to prescribe drugs using a tailored formulary and supported by strict guidelines and protocols [40]. In such a dynamic context medical work practices and professions are therefore less tightly coupled than one would expect. The question of who is involved in medical work and whose tasks are being supported we seek to answer by examining the support base for transformations of medical work practices.

In our account of the implementation of computerized physician order entry systems in two Dutch hospitals we described medical work as partly consisting of creating and entering medical orders. The success and failure model based on the centrality of medical work and its interdependencies helped us to compare and understand the outcomes of the implementation of the CPOE systems. The implementation of CPOE in hospital A can be considered a failure. The change of medical work practices of creating and entering orders with the help of an information system did not receive a support base among physicians and no other group stepped in to fill the void. Similarly the implementation of CPOE in hospital B can be seen as a success because the process of computerized order entry received a support base, but not among physicians as was originally intended. Yet we would like to introduce nuance with regard to the question of system implementation failure. As is often the case, failure was not the result of wrong decision-making or other clearly identifiable causes but the coming together over time of contingencies such as the specific technologic history and organizational conditions.

## 8. Conclusion

In order to understand the different outcomes of the implementation of a CPOE system in two Dutch hospitals we developed a heuristic model based on Sauer's failure model of dependencies. In our model we focus on medical work (practices) that will change as a result of implementing a CPOE system. Accepting or rejecting an information system will depend on whether those involved in the medical work practices will accept a transformation of these practices. The power of the model lies in the fact that it allows the analyst to understand the role of and focus on medical work practices to implement systems successfully. Furthermore, we argue that identifying factors that determine success or failure is very difficult because often implementation decisions that were completely sensible at the time they were made often prove to be constraining in hindsight. Yet we have only here made a modest start: it remains still a daunting and elaborate task to understand the nature and context of medical work practices.

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# CHAPTER 4

## A COMPARISON OF HOSPITAL-BASED COMPUTERIZED PHYSICIAN ORDER ENTRY IN THE NETHERLANDS AND USA, PART I: IMPLEMENTATION STRATEGIES

Jos Aarts, Dean F. Sittig, Joan S. Ash, Marc Berg


### Abstract

*Objective*
To compare the implementation strategies of hospital-based computerized physician order entry systems in the Netherlands and USA.

*Design*
Analysis of case studies of CPOE implementation in Dutch and American hospitals.

*Measurements*
Interview transcripts, implementation documents and published articles concerning the implementation of CPOE systems in three Dutch and three American hospitals were analyzed with regard to implementation strategies.

*Conclusions*
Implementation strategies do not differ substantially between Dutch and American hospitals. Implementation lead times tend to be about five years, which lends credibility to the suggestion that these long organizational acclimatization periods are integral to an implementation process.


Submitted for publication.

## 1. Introduction

Computerized physician order entry (CPOE) is defined as a process that allows a physician to enter medical orders directly into a computer rather than handwriting them and having a third party enter them into the computer system [1]. CPOE systems have been implemented in many different countries in the world including, but not limited to: United States, United Kingdom, Japan and the Netherlands [2-6]. Among others, two IOM reports on patient safety and quality of the health care system have recommended the implementation of CPOE systems to improve patient outcomes [7, 8]. The findings and recommendations also drew attention in Europe and have prompted several governments to assess medication safety issues and develop plans for actions. For example, the Netherlands has decided to introduce a national electronic medication record [9].

In two papers the results are presented of an international, cross-site, qualitative study of the implementation of CPOE systems in the Netherlands and USA. The aim of the study is to understand and explain the resemblances and differences of implementing CPOE in two different countries. This paper addresses the implementation strategies focusing on the dynamics of introducing CPOE in hospitals. The companion paper focuses on the involvement of physicians since CPOE systems are designed to support the physician responsibility and task of managing medical orders. Physicians merit special attention because they enjoy in the different countries a considerable degree of professional autonomy. However, increasingly they are held accountable for the outcome of their medical practices because of budgetary, quality and medico-legal reasons.

Arguably the differences in the health care systems across western countries are considerable. It varies from completely state run systems such as the United Kingdom National Health Service to mixed public and private systems existing in most western European countries and mostly private systems such as in the USA. Even within the USA different health systems co-exist. For example, health maintenance organizations are closed systems that tie together patients, providers and health insurers co-exist with public systems such as Medicare/Medicaid. Despite these differences hospitals are quite similar in their operation and the services they provide, allowing thus a comparison of hospital-based CPOE.

The comparison is limited to hospitals. CPOE has been implemented in primary care organizations in the USA, while this is not the case in the Netherlands. Moreover, primary care systems in the Netherlands and the United States differ to a greater extent thus making comparisons more difficult. In the Netherlands primary care is in the hands of general practitioners, and in the USA it can vary from large primary care organizations offering a wide variety of medical services to single practice physicians.

Several quantitative and qualitative cross-site studies of CPOE system implementations across the USA have been conducted in the period 1998 – 2003 [2, 10-16]. There are no international cross-site studies reported.

## 2. Background

In this study implementation encompasses the trajectory of introducing an information system from the idea that such a system is needed to address perceived organizational problems up to the dynamics of use in work practices. In a study of introducing CPOE in a large university medical center in the Netherlands Aarts et al. have argued that implementing a system is a thoroughly social process and therefore the implementation of information systems in health care is far from a straightforward process characterized by clearly defined inputs and outputs [6]. Markus argues that an implementation strategy should be informed by a diagnosis of the organizational setting and Dourish argues that this strategy should inform the application functionality and usage [17, 18]. Lorenzi et al. describe how an implementation strategy needs to cover financial, training and project management resources next to a change management plan [19]. Ash et al. identify usability, order sets, training and support, and time as CPOE implementation issues [13]. Zmud identifies the concept of infusion, which looks at the sophistication of use of an innovation [20]. Furthermore Lauer et al. describe how implementation strategy encompasses the establishment of a project organization, the phasing of the implementation and the training of the users [21]. Combining these insights lead the authors to identify ten aspects that characterize a CPOE implementation strategy. The ten aspects are listed and explained in table 1.

## 3. Research methods

### *3.1 Selection of cases*

The comparison is based on hospital cases in the Netherlands and the USA (see table 2). In the Netherlands the cases comprise two hospitals that have been studied by the first and last author from 1997 to 2003. The third case is an academic medical center that implemented a computerized medication order entry system in the period from 1994 to 2002. The first hospital was Radboud University Medical Center (Radboud) in Nijmegen, which has used the TDS/Eclipsys 7000 system since 1997. It is an academic teaching hospital with 953 beds affiliated with Radboud University Nijmegen. It experienced a diffi-

| Theme | Aspects | Description |
|---|---|---|
| Context | Organizational setting and goals | This refers to the characteristics of the organization—teaching or non-teaching—and the goals in patient care |
| Context | Technology history | This refers to the history of installed information technology and types of application software (vendor, custom development) |
| Implementation strategy | Project organization and committee structure | This refers to the nature of the project organization, lines of authority, responsibilities and (physician) leadership issues |
| Implementation strategy | Planning and lead time | This refers to the time needed to plan for the system and implement the system up to the moment of complete or partial activation |
| Implementation strategy | Training | This refers to the training methods for users applied during implementation |
| Implementation strategy | Hardware rollout | This theme refers to what hardware—PC's, printers, network, etc.—and how it is rolled out |
| Implementation strategy | System activation | This refers to how CPOE is activated, for example, by making it operational in all units at one time or gradually, care unit by care unit |
| (Clinical) impact | Clinical contents | This covers the properties of the CPOE system implemented; for example, does it have the capability of creating order sets, or does it have decision support to monitor orders entered |
| (Clinical) impact | Setbacks | This refers to the occurrences of setbacks during implementation and how they are dealt with |
| (Clinical) impact | Infusion time | This refers to the time it takes that the full potential of the innovation becomes embedded in medical work systems [20]. This percentage can vary from 0% (no use) to 100% (use of full potential) |
| Physician involvement | | This theme, which is addressed in the companion article, refers to issues of appropriation of CPOE by physicians, changing medical work practices and models of care and changing organizational contexts |

*Table 1 - Aspects of CPOE implementation grouped into three themes*

cult implementation and the physician order entry functionality has never been activated. The second institution is Atrium Medical Center (Atrium) in Heerlen, a 1230 bed regional teaching hospital. It has also implemented the TDS/Eclipsys 7000 system. The third institution is Academic Medical Center (AMC) of the University of Amsterdam, a 1002 bed academic teaching hospital. It has implemented Torex-Hiscom (now iSoft) Medicator, a computerized medication order entry system. Medicator is now being implemented in other Dutch hospitals, which are, amongst others, Leiden University Medical Center and Erasmus University Medical Center in Rotterdam. The selected cases are representative for the current situation of CPOE implementation in the Netherlands.

The American hospitals have been selected from cases studied by the third author's research team from 1998 until 2001. The first case was the University of Virginia Medical Center (UVMC), which has used the TDS/Eclipsys 7000 system since 1989. It is a state institution that comprises a 591-bed hospital and a network of ambulatory services. It experienced a difficult implementation that has been reported in a landmark study that described how the introduction of CPOE impacted organizational culture and behavior and medical education [22, 23]. The second institution is the Veterans Affairs (VA) Puget Sound Health Care System (VAPS), with campuses in Seattle and American Lake comprising a 347 acute bed hospital and a 142-bed nursing home. CPOE has been implemented as part of the VA's Computerized Patient Record System (CPRS). The Seattle campus is one of five teaching hospitals of the University of Washington. The third institution is El Camino Hospital (El Camino), a 395-bed hospital. The hospital has implemented the TDS/Eclipsys 7000 system, which has been in use since 1971. Its implementation and use has been well documented, see for example [24-26].

### *3.2 Data collection methods*

The data in this study included the case study interviews with key leaders, project leaders, physicians, nurses, pharmacists, other health professionals and technical experts from all organizations. The methods of obtaining the data for the case studies are described in more detail in Aarts and Ash et al [6, 13, 27]. Furthermore, interviews were held with two pharmacists who were co-responsible for the introduction of Medicator in the Academic Medical Center of the University of Amsterdam. Currently the pharmacists hold respectively positions as head of clinical pharmacy and project leader for the implementation of Medicator at Erasmus University Medical Center. In addition, all published papers and documents pertaining to the hospital cases have been included in this study. The interviews were analyzed using Atlas.ti,[1] a computer application for qualitative text analysis. The ten aspects listed above were used as units of analysis.

[1] See http://www.atlasti.de

| Hospital | Radboud | Atrium | AMC | UVMC | El Camino | VAPS |
|---|---|---|---|---|---|---|
| Location of Hospital | Nijmegen | Heerlen | Amsterdam | Charlottesville, VA | Mountain View, CA | Seattle and Tacoma, WA |
| Acute beds | 953 | 1,230 | 1,002 | 547 | 395 | 315 |
| Annual admissions | 24,494 | 27,928 | 23,642 | 29,207 | 20,846 | 11,924 |
| Annual outpatient visits | 381,075 | 432,119 | 332,394 | 621,993# | 553,430 | 482,701 |
| Full Time Employees | 5,902 | 2,007 | 5,335* | 5,290 | 2,000† | 2,643 |
| Attending Physicians | 335 | 188 | 473 | 687 | 600‡ | 186 |
| House Staff | 321 | 80 | 335 | 687 | - | 147 |
| Clinical Service Profile | Academic tertiary | Tertiary | Academic tertiary | Academic tertiary | Tertiary | Tertiary - adults |
| CPOE system | Eclipsys E7000 | Eclipsys E7000 | iSoft Medicator | Eclipsys E7000 | Eclipsys E7000 | CPRS |

# These include home health visits.
* Approximate value.
† Approximate value.
‡ Approximate value. The figure refers to both medical group physicians on medical staff as hospitalists. The medical group physicians are not employed by the hospital.

*Table 2 - Description of cases*

## 4. Results

There is a large gap between wish and reality when it comes to CPOE. Several studies have shown that in the US no more than 10% of acute care hospitals have implemented CPOE [2]. The situation in the Netherlands is comparable. The number of hospitals in the Netherlands that have implemented CPOE is also very low. Out of a 100 acute care hospitals probably no more than five have implemented order entry systems of which three are reported in this study. However, a number of hospitals have announced to introduce some form of order entry systems. The aspects have been clustered in three overarching themes: context, implementation strategy and (clinical) impact. See table 1 for the grouping of the units.

## 5. Context

### *5.1 Hospital characteristics*

Three of the six hospitals are academic teaching hospitals, where students and house staff are being trained. Both in Dutch and American hospitals medical students do not write orders, but house staff take a major responsibility for writing orders supervised by attending physicians. VAPS serves a particular group of patients—retired military personnel and their family members—and is affiliated with the University of Washington Health System and in this respect will be considered as an academic teaching hospital. As a major regional hospital Atrium trains both medical students and house staff as part of an agreement with Maastricht University and the Royal Dutch Medical Association medical specialist training supervisory committees. El Camino has no medical teaching responsibility. The academic teaching hospitals including VAPS employ their physicians. Atrium and El Camino do not employ their physicians, but have contractual agreements with them to provide for medical care. Radboud, AMC and Atrium in the Netherlands and the academic teaching hospitals in the United States are very similar in operation. They all are tertiary care referral centers where physicians provide for complex medical care on a 24/7 scheme. El Camino physicians may see and treat their patients in their private community offices and when necessary continue to treat them in the hospital. They divide their time between their private offices and the hospital. Increasingly community hospitals and medical groups hire hospitalists—primary care physicians or internists—to provide for around the clock basic medical care in the hospital.

### *5.2 CPOE systems*

The CPOE systems in all six hospitals are commercially, or in the case of VAPS freely, available products. The development history is however quite different. El Camino was the first hospital to implement CPOE; the system was developed in close collaboration with Lockheed and later Technicon Data Systems and became operational in 1974. The incentive at the time was to save costs and the agreement between El Camino and Technicon stipulated that the company would take the risk of financial losses and pass on the savings to the hospital. The history has been well documented by Hodge and Collen [24, 26]. The same TDS system has been implemented in Virginia, Radboud and Atrium in the period from 1985 to 1997. The need of clinical efficiency—by improved legibility and completeness of orders—was the main reason for these hospitals to acquire the system. The VAPS CPOE system is an integrated part of a nationwide implementation of CPRS in the Veterans Affairs medical centers [28]. VAPS was a beta test site for the CPRS functionality. The project started early 1997 and CPRS became operational in December 1998. The main reason for implementing CPRS was again the need to improve clinical efficiency and to increase the quality of care. In AMC clinical pharmacists initiated the implementation of Medicator. The illegibility and incompleteness of written drug prescriptions and the use of non-conclusive short-names for drugs were seen to contribute to logistical problems, which could result in patients receiving inadequate pharmacotherapy [5]. Medicator was developed in 1994 as part of the hospital information system and piloted in three clinical departments. As a result of the positive outcomes of the pilots and the support of residents the hospital board authorized in 1996 the implementation of a Windows emulation of the application and it became operational hospital wide in 2001.

### 5.2.1 Implementation strategy

An IT-implementation strategy may be described as establishing a series of activities and an organizational structure to arrive at an operational system that serves organizational purposes. It contains both technical aspects such as the rollout of hardware and organizational aspects such as the training of prospective users and change of work procedures. Usually some organizational structure with a steering or oversight group, project leaders and members and user committees is set up.

## 5.3 Project organization

All hospitals had a project structure in place. In the Dutch hospitals projects tended to be of a temporary nature, the tasks of maintaining, updating and training being absorbed into existing structures such as an IT-department as soon as the implementation was considered finished, while the American hospitals established more permanent structures by creating a physician lead position and physician committees for the development and implementation of clinical content, guidelines and protocols. The latter approach indicates the importance attached by the American hospitals to clinical use of CPOE. The formal decision-making authority rests with the steering committee or chief hospital executive. However, without an appropriate network of support they are not able to function. The Dutch project structures tended more to make decisions by negotiating and consensus building; the American project approach emphasized leadership. VAPS was for example very intent in creating a physician leadership role; this would at the one hand facilitate acceptance of the CPRS by physicians because the physician leader would be considered as one of their peers and at the other hand he would be seen as the person with decision authority. The Radboud project team had to negotiate each decision with various stakeholders and could not even be sure whether decisions would be implemented. Similar findings were reported in Atrium. In the AMC the hospital board had to put in its full weight to have the decision to implement CPOE accepted, but not after having ascertained the support of the residents.

## 5.4 Lead time

Implementation lead time is defined as the duration of the introduction of CPOE from the first time that the need for CPOE is identified until the moment that the system is available for use throughout the hospital. In every case the decisive moments could not be easily identified, but from the interviews and published papers it became clear that an implementation lead time of at least five years is common. Only VAPS reported a much shorter time of two years, from 1997 to 1999, but it should be noted that the predecessor of CPRS with limited order entry capability was already implemented in 1995. If that fact is taken into account then the implementation lead time comes close to the figure of the other hospitals. The implementation lead times of the six hospitals are listed in table 3.

| Lead time | Radboud | Atrium | AMC | UVMC | El Camin | VAPS |
|---|---|---|---|---|---|---|
| Start CPOE project | 1988 | 1990 | 1994 | 1982 | 1969 | 1995 |
| End CPOE project | 2000 | 1997 | 2001 | 1992 | 1974 | 1998 |
| Duration | 12 years | 7 years | 6 years | 10 years | 5 years | 3 years |

*Table 3 - CPOE implementation lead time*

### *5.5 Training*

Training was highly individualized in all hospitals. During the implementation phase small teams would go out and train the prospective users. Formal training was required before the prospective user was authorized to use the system and a password could be issued. The hospitals that implemented the E7000 system used a Computer Based Training (CBT) application provided by the vendor and adapted for local use. A classroom with terminals allowed for walk-in CBT. In VAPS and AMC small groups would go to the clinical departments and train the physicians and other intended users of the system. All hospitals reported problems of physicians finding time to complete a training session. After the implementation of CPOE was completed VAPS and UVMC started training classes on a regular basis for each new groups of residents and they also relied on senior residents instructing juniors how to use the system. VAPS made a strong effort to have help readily available under the slogan 'help-at-the-elbow.' AMC also established classes for group training. In El Camino nurses were and are still instrumental in training physicians.

### *5.6 Technical infrastructure*

The CPOE systems in the hospitals run on mainframes and client/server configurations. El Camino and UVMC run E7000 on a remote IBM mainframe. Radboud has installed E7000 on its own IBM mainframe and Atrium uses also the same computer. In the early stages users connected to the system through dumb character based terminals. There was no need to use the keyboard; all data could be entered and retrieved with the help of a light pen. Later on the terminals were replaced with personal computers on which the E7000 system was emulated. The principle of not interacting with the keyboard was maintained. In the VAPS the CPRS runs on a local client/server configuration and the users use standard Windows screens to interact with the system. One of the project members at VAPS reported how in the fashion of a production line PC's were rolled out in the hospital. Similarly, in AMC Medicator as part of the hospital information system runs on client/server configuration and the interface is emulated on PC's in a Windows screen. Apart from occasional mishaps such as misplaced printers or insufficient network wiring none of the hospitals reported serious problems with hardware rollout.

### *5.7 System activation*

Activation refers to the moment that a new system goes live. Except for Radboud and VAPS all hospitals chose for a step-by-step activation of the CPOE functionality. The main reason was to allow the users to get accustomed to the system, to identify possible software problems and improve procedure for hospital wide implementation. Radboud prepared the transfer of all patient data from the old system to the new system and wanted to avoid the use of old and new system simultaneously and thus insure that patient data integrity would not be compromised by sitting in different systems. Therefore a large number of prospective clerical users were trained prior to the 'big bang.' A similar approach was planned when the order entry functionality would be activated. VAPS followed an "aggressive" policy to activate CPRS at one time in which a major care setting would start to use the system after having a stable network infrastructure and workstations installed and testing the application software for more than one year [28]. The transition was helped from day one by the 24-hour availability of CACS who offered help even in the 'dead' hours of the night. The policy was to avoid problems of patients transferring from a CPRS to a non-CPRS environment.

#### *5.7.1 (Clinical) impact*

Whether intended or unforeseen, implementing new information systems will impact users and their work practices. A more detailed account of how physicians were involved and how they were impacted is presented in the companion article.

In CPOE studies medication ordering is highly profiled, because of its significance for medical care and because it is the single most important source of medical errors. Of course it encompasses other diagnostic and therapeutic orders. An overview of computerized ordering in the six hospitals is listed in table 4. In Dutch hospitals drug order entry is gradually expanded to ambulatory clinics; a major problem is the fact that patients there do not fill their prescriptions in hospital pharmacies but in public pharmacies, which do not necessarily hold the same stock of drugs.

### *5.8 Order sets*

Personal and group order sets form part of the CPOE implementations in the American hospitals. The order sets result from a desire to group orders for designated groups of patients. Personal order sets belong to an individual physician to address the needs of certain type of patients that he sees frequently. Group or departmental order sets reflect a common understanding or agreement concerning what orders should be initiated for particular groups of diseased patients. The order sets were mainly physician driven. They had been developed to make the ordering process more efficient. In the E7000 system the number of screens to be paged was reduced to save the physician time. This became for example a critical issue in the University of Virginia Medical Center after the residents protested that they had to spend too much time on entering orders [22]. A UVMC surgeon summarized how he addressed the problem of grouping orders: "We tried to make it even better than that, so I'm a surgeon, if I do a gall bladder operation, it's fairly standard in terms of what I want for my patient and so we had constructed an order set for a patient that was gonna have a gall bladder removed, they'd come in the hospital and they had a certain standard set of orders that, dose of antibiotics was already written and ordered so you had to no clicking, you just clicked on it to check it basically and so now you could go down a check list. So it had vital signs all written out, it had admit, it had, you know, NG tube orders, it had your drugs, it had NTO, it had one that you could just click the things you wanted, and scroll the screens as if you were going through a preprinted page of orders. And that became the most efficient thing, at least for us." Creating personal order sets is the first step of grouping orders. An El Camino nurse described how a personal order set is a limited set of orders for a small type of procedure: "An example would be a bowel prep. We have a patient, and he's going to come in and he's going to have a lower anterior resection tomorrow. And it's not really a clinical pathway. To do a bowel prep you don't really need a clinical pathway. But one of the surgeons has a personal order set for his standard bowel prep." Clinical pathways are the next step in the grouping of orders. They entail for a given disease group a whole set of evidence based diagnostic and therapeutic procedures and that are implemented department- or hospital-wide. A clinical pathway implies the collaboration of different medical specialties and other health care professionals. El Camino had implemented clinical pathways to a greater extent than the other American sites. The cost benefits and efficiency perspective dominated this move. In AMC the pharmacists took a lead in developing departmental order sets, which include both simple and complex medication protocols. This reflects the fact that in the Netherlands pharmacists are co-responsible for the quality of prescribing. Medicator does not allow for the development of personal order sets. Atrium did not implement personal and departmental order sets. Nurses page a number of screens in a fixed sequence for each order that they enter.

| **Computerized ordering** | **Radboud** | **Atrium** | **AMC** | **UVMC** | **El Camino** | **VAPS** |
|---|---|---|---|---|---|---|
| *Inpatient* | | | | | | |
| Medications and other therapeutics | - | + | + | + | + | + |
| Diagnostic tests | - | + | - | + | + | + |
| Patient care and therapy | - | + | - | + | + | + |
| Consults and referrals | + | + | - | + | + | + |
| *Ambulatory* | | | | | | |
| Medications and other therapeutics | - | + | + | + | + | + |
| Diagnostic tests | - | + | - | + | + | + |
| Patient care and therapy | - | + | - | + | + | + |
| Consults and referrals | + | + | - | + | + | + |

*Table 4 - Computerized ordering (after [14])*

### *5.9 Decision support*

Decision support is seen as an intrinsic part of CPOE and indispensable for individualized care [29]. However, decision support should not be identified with the presence of an active intelligent agent that takes context into account. As part of a CPOE system it helps the physician to make decisions by constraining choice in the form of tables of allowed drugs or in the form of rules about drug prescription such as dosages, drug-drug interactions and possible adverse drug events, etc. In all hospitals decision support is part of the CPOE system. VAPS seems to have the most advanced application of decision support of the hospitals in this comparison. The decision capabilities are listed in table 5.

### *5.10 Setbacks*

When complex information systems are implemented, inevitably setbacks occur. Setbacks may delay the implementation process or even halt them. All hospitals in this comparison reported setbacks. After an initial successful implementation El Camino experienced around 1975 strong physician opposition. When more orders were coded into the CPOE system, physicians complained that they were spending too much time at the terminal. Apparently the problem was resolved after more training was offered and when it was made clear that the system wasn't going away. At VAPS an earlier attempt to implement CPOE was aborted, again because of a time issue compounded by the com-

| Type of decision support | Radboud | Atrium | AMC | UVMC | El Camino | VAPS |
|---|---|---|---|---|---|---|
| Drug name checking | - | + | + | + | + | + |
| Default administration route | - | + | + | + | + | + |
| Listing by formulary | - | + | + | + | + | + |
| Patient drug allergies (simple – specific drugs) | - | + | + | + | + | + |
| Patient drug allergies (advanced – drug families) | - | + | + | + | + | + |
| Protocol or diagnosis based therapy | - | - | + | + | + | + |
| Duplicate order checking | - | + | + | + | + | + |
| Drug – drug interactions | - | + | + | + | + | + |
| Substitute therapy suggestion | - | - | - | - | - | + |
| Subsequent or corollary orders | - | - | - | + | + | + |
| Default doses | - | + | + | + | + | + |
| Relevant information display | - | - | + | - | - | + |
| Drug cost display | - | - | - | + | + | - |
| Guided dosing calculation | - | + | - | + | + | + |
| Time based checks to ensure optimum timing and duration | - | - | + | + | + | + |
| Administration route change | - | + | + | + | + | - |
| Drug – laboratory interactions | - | - | - | - | - | - |

*Table 5 - Decision support for computerized ordering of medications (after [14])*

plexity of the software. The opposition of house staff to mandatory CPOE at UVMC has been widely cited; Massaro found four factors that contributed to the organizational stress: the change of the established workflow, the literal interpretation of rules by the CPOE system and, ambiguity of governance policies and a lack of understanding within the physician community of the strategic value of the system [22]. Ultimately the solution was the introduction of departmental and personal order sets, which allowed physicians to group orders and made the ordering process more effective than the handwriting of single orders [23]. Setbacks were also reported in Dutch hospitals. AMC reported a delay in the implementation process because of lack of personnel. Atrium and Radboud reported more severe setbacks. Physicians in Atrium opposed the introduction of CPOE arguing that it was not their job to do clerical tasks. The board of directors allowed them to stay out of the loop; nursing and clerical staff appropriated the system [30]. Radboud experienced a major setback when physician pressure forced it to abort the implementation of the CPOE functionality of the E7000 system [6]. It was the accumulation of a series of mishaps where it turned out that contrary to expectations the use of the system was very time consuming. The four factors identified by Massaro had a familiar ring in this case too.

### *5.11 Infusion*
With any implementation it is hoped that after some time all intended users would use the system. How it is achieved is dependent on different factors, which include the way the implementation is planned, training and the acceptance by the users. The American hospitals and AMC all achieved close to 100% physician usage after a few years. Except for VAPS the hospitals reported infusion times of at least three years. VAPS managed to achieve close to 100% usage within one year. Atrium is a case in point that all orders are electronically entered, but that there is no physician usage. Depending on the perspective chosen one may observe 100% infusion from a systems perspective and 0% infusion from a licensed professional perspective. This issue will be assessed further in the companion paper. Radboud did not at all achieve CPOE functionality, so infusion is 0%.

## 6. Discussion
One is struck by the similarities of the CPOE system implementation trajectories in both Dutch and American hospitals. Technology and software issues of CPOE in hospitals showing up in the comparison have already been discussed elsewhere. This discussion will focus more on the socio-organizational issues of implementing CPOE.

The reported reasons for each of the hospitals to implement CPOE were based on cost-savings and improving efficiency of medical ordering by reducing illegibility and increasing completeness. It was only later, after the publicity around the publication of the IOM reports 'To err is human' and 'Crossing the quality chasm' that issues of safe drug prescribing and patient safety became dominant in the discourse to implement CPOE. The Dutch Government Health Inspectorate was similarly able to bring the same issues to the forefront and initiate initiatives that would improve patient safety such as mandatory reporting on quality indicators. Despite the fact that the involvement of physicians is crucial for the successful use of CPOE systems, the implementation seems to be a mainly managerial driven effort with the exception of AMC. In AMC pharmacy was the driving force for the development and implementation of Medicator. Their problem was drug prescribing and Medicator was specifically designed to support just that and geared towards the needs of the hospital pharmacy.

The project structures in Dutch and American hospitals tend to be different. Dutch projects tend to be based on the equity of its members and decision making by consensus, whereas American project structures tend to emphasize leadership, whether it is in the person of a chief hospital executive in the lead (UVMC and El Camino) or a physician (VAPS). Dutch project leaders are more dependent on negotiating and compromising, a lack of which can compromise a project, as was the case in Radboud where no agreement with medical staff could be reached to implement CPOE functionality. American leadership tends to articulate goals more clearly and emphasize change management [31]. Those who oppose change must be identified and the right measures have to be taken in order to overcome resistance. In such a view it is necessary to know the attributes that characterize resistance and to address each of them [32]. The implementation of CPRS in VAPS is a good example of the emphasis on successful leadership [33]. The leader was visible, goal oriented, very knowledgeable about the subject matter, encouraged clinicians and as a practicing physician, accepted by his peers. However, a closer look at the cases reveals that the differences were not so absolute. For example, when the implementation of CPOE seemed to founder in the UVMC, negotiations with house staff representatives became necessary. In AMC the hospital board backed the policy of the hospital pharmacy to allow only electronic drug prescribing and the physicians complied.

Training is seen as key factor for successful implementation of an information system. Contents and timing are important. Wrong timing can delay the activation of a system, which happened in Radboud. But often implementers do not pay sufficient attention to training needs of users when the system is operational. Often users are then confronted with problems of use that requires at least support and more often further instruction. The implementation of a hospital information system in the University of Geneva Cantonal Hospital in the 1970s and 80s was so successful because after the system became active instructors would remain available 24 hours per day [34]. When a user would encounter a problem, he or she could pick up the phone next to the terminal and get support from an instructor who could see on his screen what the user was trying to do. Only at VAPS health professionals were trained as Clinical Application Coordinators to provide “extremely thorough” customer support, including training [33]. The fact that CPRS was up and running within two years may be attributed to that fact.

The account of activation of the system in the hospitals seems to posit a ‘big bang’ approach against a step-by-step approach. However, the dichotomy is not as black-and-white as the terms suggest. In Radboud the CPOE system was activated hospital-wide, but the functionality was only limited. The planning foresaw that first radiology ordering would be activated, then lab ordering and finally medication ordering. Similarly AMC activated full functionality of Medicator department-wise. Step-by-step implementation can thus be defined as activating a limited functionality hospital-wide or a full functionality per clinical department.

The CPOE implementation lead times for all hospitals were, except for VAPS, a minimal of five years. The lead times were not reported as such but could be construed from the interviews and the papers that describe the introduction of CPOE. VAPS reported an implementation lead time for CPRS of three years, but it must be noted that the implementation of an earlier version of a VA computerized order entry system failed. If that is taken into account, then the lead time comes close to that of the other hospitals. Such long lead times may be contradictory to the dictum of dynamic change in health care, which implies that organizations are in a constant flux. In such view long implementation lead times are seen as detrimental to respond to change. It lends however support to the suggestion by Aarts et al. that such long lead times, or organizational acclimatization periods, are necessary for the mutual learning process to develop and implement information systems [6]. If long lead times are part and parcel of an implementation process, then it must be accepted that long-term planning can be difficult. Rather, implementation trajectories change over time and are inherently unpredictable [35].

## 7. Conclusion

The implementation strategies of three Dutch and three American hospitals have been compared. The implementation strategies do not differ substantially. All hospitals emphasized that the need to save costs and increase efficiency of health care delivery were the main reasons to introduce CPOE. In the last five years patient safety has become an important reason to implement CPOE, but emphasis remains on cost savings. A report on the adoption rates of CPOE in Massachusetts still phrases the benefits of CPOE in terms of costs benefits and asks the rhetorical question [36]: “So if a $210 million investment can generate on-going savings of $275 million, not to mention significantly improve patient safety and care, what’s keeping that investment from happening?” Discourse suggests that project organization in American hospitals tend to be more centered on leadership, while in Dutch hospitals it is centered on negotiation and compromise between stakeholders. However, the difference between the two is more characterized as a sliding scale. No hospital questions the need of adequate training, but the example of VAPS shows how training combined with user support around the clock led to a successful implementation. The implementation lead time of CPOE systems on average is a minimum of five years if setbacks are taken into account. This lends credibility to the suggestion that long times are necessary for the mutual learning process of developing and implementing systems.

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# CHAPTER 5

## A COMPARISON OF HOSPITAL-BASED COMPUTERIZED PHYSICIAN ORDER ENTRY IN THE NETHERLANDS AND USA, PART 2: PHYSICIAN INVOLVEMENT

Jos Aarts, Dean F Sittig, Joan S Ash, Marc Berg

### ABSTRACT

*Objective*
To compare physician involvement in the implementation of hospital-based computerized physician order entry systems in the Netherlands and USA.

*Design*
Analysis of case studies of computerized physician order entry (CPOE) implementation in Dutch and American hospitals.

*Measurements*
Interview transcripts, implementation documents and published documents concerning the implementation of CPOE systems in three Dutch and three American hospitals were analyzed with regard to the involvement of physicians.

*Conclusions*
CPOE implementation initially does not meet the perceived needs of physicians. However, once physicians appropriate CPOE as part of their work practices they are able to add sophistication in the form of departmental order sets. Furthermore as socialization process medical education can help adopt CPOE.

Submitted for publication.

## 1. Introduction

The involvement of physicians is a very problematic aspect of the implementation of computerized order entry (CPOE) systems. A survey in 1998 by Ash et al. has shown that physician use of CPOE in many hospitals that have implemented CPOE does not exceed 50% [1]. Later surveys do not show a substantial change [2, 3]. In a survey Poon et al. found that management officials cited costs and physicians resistance as the most significant barriers to implementing CPOE systems [4]. In their study Poon et al. cite reasons like the superior speed of completing a paper-based order from the physician's perspective and a low computer literacy level. Scholars have sought to understand how physicians were involved in information technology and to identify the barriers that might prevent them from adopting IT in their work practices. For example, Massaro found in his study of CPOE implementation in the University of Virginia Medical Center that physicians did not like the amount of time they had to spend entering orders in a computer system [5]. In a review of computerized prescribing Schiff and Rucker suggest that physicians do not value the benefits because they are too busy and "microfocused" to appreciate the shortcomings of paper-based prescribing practices [6]. Silverstein regrets the poverty of physician leadership but emphasizes that IT personnel needs to have a deep understanding of medical work practices [7]. He suggests that physicians are less inclined to go along with top-down IT implementation methodologies but favor a participatory approach to application development as described by Sjöberg and Timpka [8]. In a wider context Blendon et al. found that physicians did not have the sense of urgency about medical errors and Rosen et al found that they are skeptical about the interventions such as CPOE to address them [9, 10]. At the very least critical remarks are placed about the involvement of physicians in introduction of new information technologies in health care, at most the understanding of the involvement is still very fragmentary.

The purpose of the study presented in this paper is to understand how physicians are involved in CPOE by making a comparison of physician involvement in CPOE implementations in three hospitals in the Netherlands and three hospitals in the USA. Specifically three questions are addressed. How are the physicians engaged in the implementation of CPOE? How do they appropriate CPOE? How does CPOE impact medical work practices? The concept of appropriation refers to the process by which people adopt and adapt technologies, fitting them in their working practices [11].

## 2. Background

In order to understand the different outcomes of CPOE implementation in two different hospitals Aarts and Berg developed a model that puts medical work at its core and argued that in order to implement CPOE successfully changing medical work practices need to have a support base [12]. This requires a thorough understanding of medical work and how the introduction of new information technologies might change it. Massaro identified the strict, literal interpretation of rules by the computer as one of the factors that contributed to the organizational stress that accompanied the implementation of CPOE [5]. In their study of ordering medication before and after implementation of a CPOE system Goorman and Berg noted that the system is based on an "abstract conception in which medication is always ordered and prescribed by a doctor, who gives the order to the nurse, who in turn, gives the medication to the patient [13]." They further note that: "this standard model does not reckon with the fact that in daily practice there are many practical and good reasons for nurses to order medication." In their study of CPOE systems Gorman, Lavelle and Ash conclude that the underlying model seems to be based on a rather simplistic, linear step-by-step sequence for processing orders, that does not reflect the collaborative nature of medical ordering [14]. These observations about the interaction of CPOE systems with medical work suggest that it might too simplistic to explain physician resistance in terms of their behavior. This is not to say that introducing IT will not change or should not change medical work practices. Groth argues that IT should be introduced with the objective to make (medical) work better, especially in terms of coordinating tasks [15]. The companion paper suggests that CPOE implementations tend to be managerial-driven without much understanding of the complex nature of medical work. Therefore medical work is taken as a focal point in the comparative analysis of physician involvement of CPOE implementation. More specifically, in trying to answer the research questions addressed in this paper the comparison tries to identify how medical ordering was taking place before CPOE, how and what type of physicians were engaged in the implementation and use of CPOE, how they appropriated computerized order entry and what impact was reported on workflow and behavior.

## 3. Research methods

### *3.1 Selection of cases*

The comparison is based on hospital cases in the Netherlands and the USA. The selection of the cases is described in detail in the companion paper. The hospitals and their systems are listed in table 1. Atrium Medical Center (Atrium) in the Netherlands, El Camino Hospital (El Camino), the University of Virginia Medical Center (UVMC) and the Veterans Affairs Puget Sound Health Care Systems (VAPS) in the United Sates have implemented a fully functional CPOE system. The Academic Medical Center of the University of Amsterdam (AMC) has implemented a medication CPOE system and in Radboud University Medical Center (Radboud) the implementation of the CPOE functionality failed. Fuller details about the hospitals can be found in the companion paper.

| **Hospital** | **Radboud** | **Atrium** | **AMC** | **UVMC** | **El Camino** | **VAPS** |
|---|---|---|---|---|---|---|
| Location of Hospital | Nijmegen | Heerlen | Amsterdam | Charlottesville, VA | Mountain View, CA | Seattle and Tacoma, WA |
| Acute beds | 953 | 1,230 | 1,002 | 547 | 395 | 315 |
| Annual admissions | 24,494 | 27,928 | 23,642 | 29,207 | 20,846 | 11,924 |
| Annual outpatient visits | 381,075 | 432,119 | 332,394 | 621,993# | 553,430 | 482,701 |
| Full Time Employees | 5,902 | 2,007 | 5,335* | 5,290 | 2,000† | 2,643 |
| Attending Physicians | 335 | 188 | 473 | 687 | 600‡ | 186 |
| House Staff | 321 | 80 | 335 | 687 | - | 147 |
| Clinical Service Profile | Academic tertiary | Tertiary | Academic tertiary | Academic tertiary | Tertiary | Tertiary - adults |
| CPOE system | Eclipsys E7000 | Eclipsys E7000 | iSoft Medicator | Eclipsys E7000 | Eclipsys E7000 | CPRS |

# These include home health visits.
* Approximate value.
† Approximate value.
‡ Approximate value. The figure refers to both medical group physicians on medical staff as hospitalists. The medical group physicians are not employed by the hospital.

*Table 1 - Hospitals and their CPOE systems*

### *3.2 Data collection methods*

The data in this study included the case study interviews with key leaders, project leaders, physicians, nurses, pharmacists, other health professionals and technical experts and were conducted from earlier published research by Goorman and Berg, Ash et al, and Aarts et al [13, 16-18]. Additional interviews were held with two pharmacists involved in the implementation of the medication CPOE system in the Academic Medical Center of the University of Amsterdam (AMC). In addition, all published papers and documents pertaining to the hospital cases were included in this study [5, 19-25].

The interviews were analyzed using Atlas.ti,[1] a computer application for qualitative text analysis. The above-mentioned themes—medical ordering prior to CPOE, engagement of physicians, appropriation and impact—were used as units of analysis.

[1] See http://www.atlasti.de

## 4. Results

### *4.1 Order entry prior to CPOE*

The interviews were conducted in the period from 1997 to 2004. The description of the process of medical ordering prior to CPOE is therefore to a large extent based on memory of the interviewed persons and earlier published papers. At El Camino Hospital little is known about medical ordering before CPOE, which has been in place since 1975. However, because El Camino was a community hospital nurses played an important role in patient care. The physicians would usually see patients in their private offices and only come to the hospital for their hospitalized patients. One of the nurses noted: "I think that El Camino has had a long history of a very close working relationship between the nurses and the physicians. The physicians, I think, have high regard for the nurses here …" The nurses then would ensure the continuity of care in the hospital since they are around 24 hours a day, 7 days per week. This situation allowed the nurses much leeway to manage patient care and it might explain why nurses still took verbal and telephone orders from physicians and entered them in the system. It is therefore very likely that before the implementation of the CPOE system verbal and telephone orders were quite common. At the University of Virginia Medical Center according to Massaro prior to CPOE an order was written in the chart on the patient's unit and the charge nurse would take responsibility for the routing of the order to the bedside nurse and the pharmacy. The pharmacy would complete the order, but if any part of it was unclear the ordering physician would be paged and clarification would be obtained by telephone [5]. Similarly in VAPS physicians would write orders and interact with nurses. In Atrium the physicians were used to working with a paper based medication order system, which is easy to handle. In many cases they would rely on experienced nurses who would give patients medication when they were not around. There was even a repertoire of drugs—especially pain-relieving drugs—that was informally agreed to be controlled by experienced nurses [13]. A similar situation existed in Radboud, but in an academic medical center drug prescribing and administration, especially for the numerous clinical research programs were much more protocollized. Similar ways of working were reported in AMC.

### *4.2 Physician involvement in CPOE implementation*

As reported in the companion article none of the CPOE implementations were physician driven. In the AMC the implementation of Medicator came closest to addressing a clinical need, because hospital pharmacists took the view that they could not take co-responsibility for medication orders unless the orders were correct and complete and thought that a computerized drug order system could help them. However, from early on physicians were engaged in the implementation process of CPOE systems. In his account of the El Camino CPOE system implementation in the 70's Hodge quoted newspaper headlines informing how the physicians responded to the new system [20]. The new system was clearly not perceived as solving problems in medical work practices.

**Doctors look with ill favor at new computers**

**Physicians deeply split over "dream computer"**

**"Work-saving" computer enslaves hospital staff, doctors claim**

**MDs at odds over hospital MIS**

**"Computer doesn't help doctors or patients"**

**Hospital computer unimpressive**

*Figure 1 - Newspaper headlines about CPOE implementation in El Camino Hospital, 1972 – 73 (Source: [20])*

Massaro characterizes aptly how the physicians were engaged in committees that were supposed to develop policies for the implementation of CPOE but actually were used for enforcing policies that were drafted at executive level [5]. Such an approach did not help to engage physicians. The implementation of CPRS in VAPS was part of a government decision to implement the system in all VA medical centers. This was clearly a top-down decision. VAPS returned this decision into their favor by applying to be a beta test site. VAPS was granted that position because it was a considered a large site that could provide valuable input to other centers. After a failed implementation of a previous CPOE system, VAPS appointed a physician leader with authority who would be able to bring the physicians on board. He succeeded by emphasizing the clinical needs of the physicians, involving them in its development and providing support by clinicians who were trained as system developers and trainers. Though it was a vendor system, it was seen as homegrown, a system that the physicians felt ownership of. The physician leader focused on residents, who took daily care of patients, supervised by attendings. In the AMC pharmacists found three clinical departments willing to pilot Medicator. A breakthrough came when residents in the department of pediatric oncology found that the system was extremely helpful in managing complex cancer medication trajectories. Consequently they had pharmacy enter all their medication protocols in the system. The residents convinced the board of directors of AMC to keep the system and put in its full weight to implement Medicator hospital wide. In Atrium, physicians stayed out of the loop despite the presence of a physician in the CPOE implementation team. In Radboud staff physicians were involved in the implementation of the CPOE system. A medical specialist was even made project leader. Pilots were set up to test the order entry functionality and were positively valued by the participants. However, it was not sufficient to enroll the support of the clinical staff as a whole, especially when the setbacks experienced in the use of the clerical part of the system made them believe that using it would cost them too much time [17].

### *4.3 Appropriation*

Except for Radboud and Atrium physicians used CPOE systems to enter their orders. A closer examination of physician order entry revealed that in UVMC, VAPS and AMC residents entered orders and attendings did not. In these hospitals entering orders electronically is seen as part of the skills of drug prescribing that residents have to acquire. Indeed, American teaching hospitals have house staff training manuals that stipulate what, how and when house staff officers learn about drug prescribing including the use of computerized order entry. The years of residency determine the complexity of the medications that they are allowed to prescribe. In UVMC after the apogee of resistance the introduction of personalized and departmental order sets proved to be very effective [21]. Residents were allowed to develop and enter personalized order sets on an ad hoc basis, which saved them much time. Within two years there were over 2500 order sets. A resident-led oversight committee later reduced this unwieldy number to a little over 500. Similarly, the development of order sets in VAPS and electronic medication protocols in AMC were facilitated by clinician committees.

As mentioned before, in El Camino nurses played a crucial role in the physician acceptance of CPOE. They trained them how to use it, and helped prepare order sets and from the 1990's clinical pathways that made the delivery of care more efficient. This was not without self-interest. Because the physicians would only come to the hospital for their hospitalized patients, it saved both the nurses and physicians an enormous amount of time when it would already be known what should be done. Clinical pathways were developed for a sizeable number of health problems, and were implemented in the CPOE system. El Camino physicians could enter orders from their private offices and care activities would already be on their way when they came to see their patients. Also nurses were allowed to enter follow-up orders, including medication refills.

In Atrium physicians did not use CPOE and consequently no order sets were developed. Nurses and secretaries as a proxy to the ordering physician would enter each order for a patient separately.

### *4.4 Impact*

Impact in a broader sense has been presented in the companion article. Taking medical work as focus of analysis, physicians reported that CPOE affected especially their communication with nurses. Depending on the situation, a physician would collate the orders and enter them at once for all patients they had seen or after each patient. During rounding a physician would write orders on his notepad and after rounding enter them in the system. Or a physician would enter immediately the orders in the system after having seen a patient. In the hospitals networked PC's could be found in physician offices, physician meeting rooms and nurses' stations. No PC's were installed in patient rooms. Physicians who were using CPOE and who had experience with paper-based ordering reported that it impacted them and especially their relationship with nurses. A physician at VAPS commented: "I think it actually probably does interfere with communication – direct communication between physician and nurse. Just because you don't have to be next to the person or hand the order to the nurse." This would give the nurse the ability to comment on the order or add insights. Also, she would immediately know what needed to be done in the next few hours. This immediacy of contact would be lost and could not be easily compensated by electronic alerting systems that would inform the nurse about standing orders. Also this impact on medical work practices did not go unnoticed to nurses. A project pharmacists at VAPS observed: "Well, I know that the nurses have complained, and still complain, that now that the physicians don't have to come to the ward to enter their orders and write notes, they don't see them there so they can't ask that Oh-by-the-way question." At UVMC Massaro reported that introducing CPOE caused nursing personnel to be taken out of the ordering loop and that their assistance was no longer available.

Not always was CPOE seen as detrimental to communication. According to a project nurse at El Camino the availability of all orders in the system allowed the nurse to be better prepared to communicate with physicians when they were rounding. According to another project nurse CPOE has caused everybody in the hospital to be more interdependent: "It used to be the department could do whatever it wanted and it didn't have to impact anybody else. When the new radiology system came in, that was a special radiology system and it was more complex than the major hospital system, which is a generalist. The radiology system got picky about the orders so [CPOE] pathways had to change and the doctors hated that they were being asked more questions. That means radiology can't just throw up the system, they have to explain it to all the doctors and if the doctors don't like it there's a dialogue and they talk to one another."

## 5. Discussion

The introduction of CPOE did not meet perceived clinical needs of physicians. They saw it as something that was imposed on them by hospital management. Much effort had to be put in to enroll physicians in using CPOE. In two Dutch hospitals it failed. Different strategies were employed to involve physicians. The most important were leadership, training and user support. VAPS and AMC made physician use mandatory. In AMC the pharmacists could monitor physician use through login audits and question them if irregularities were found. In UVMC, VAPS and AMC house staff entered orders in the system. The attendings did not. In Atrium and Radboud house staff did not use CPOE. The fact that house staff are employed by the hospital cannot fully explain this situation. An additional explanation can be offered by the concept of socialization. Socialization concerns the processes by which physicians in training adopt from their supervisors the attitudes and values that they consider inherent to the medical profession [26]. If the attitude of the supervising specialist towards the use of CPOE—and electronic patient records in general—is indifferent or even negative, then it is less likely that a resident will develop a positive attitude. Both in the United States and the Netherlands residents follow their supervisors in their role as peers. In the Netherlands staff physicians in Radboud and Atrium opposed the adoption of CPOE and the residents followed them in their attitude.

In El Camino it was different. The nurses played a key role in the adoption of CPOE by physicians. At the one hand nurses trained physicians how to use CPOE and developed order sets for them and at the other hand they enjoyed more freedom to prepare and refill orders than would be the case at teaching hospitals. It can be argued that here the nurses played to some extent the role of residents. This may change because increasingly hospitalists are being hired in community hospitals to provide for 24 hours, 7 days per week care for hospitalized patients. Recent estimates suggest that the current number of 7,000 hospitalists may ultimately rise to 19,000 [27, 28]. It can be only a matter of time that they will become pivotal in the use of CPOE. According to Poon et al. some senior managers mentioned that hospitalists already served as facilitators of CPOE adoption [4].

Once physicians started to use CPOE in the four hospitals, it was interesting to note how quickly they started to think how they could make ordering more efficient and it led to an explosion of the use of personal order sets, as evidenced by the study of Massaro and the review of Payne et al [21, 23]. They found that order sets allowed them to initiate a string of activities for disease profiled patients and save them time. Their clinical expertise was crucial for the design of the order sets. In this way physicians appropriated the use of CPOE. The phase of developing personal sets can be seen as an important stepping-stone towards the more structured and evidence based development of department order sets. After the implementation process stabilized, none of the hospitals reported serious problems of physician use. Ash proposes the use of the term infusion to describe the level of sophistication of the use of an innovation [29]. The authors suggest now that infusion is not only a system property, but that clinical skills and expertise are equally important to reach a sophisticated level of use. This would explain that in Atrium nurses never used order sets, because their expertise is different from that of a physician and they work as a proxy to them. At the other hand, beyond the level of clinical expertise it is difficult for a physician to conceptualize how better care might be delivered through organizational transformation and change of medical work practices and conceptualize a new role for CPOE [30].

According to both physicians and nurses professional communication was most impacted by the introduction of CPOE. The synchronous nature of collective decision making about patient care was more replaced by asynchronous decision making by the physician when entering orders. Interviewees were also concerned about the notification process. However, it seems that after a while the concerns subsided and physicians found other ways to communicate with nurses, for example by telephoning or taking notes while rounding and nurses were more accustomed to looking up orders in the system and page physicians when necessary. Apparently new modes of communications settled in.

## 6. Conclusion

It is difficult to involve physicians in CPOE implementation if they do not perceive a need to change clinical work practices. CPOE has been heralded as a technology that would make medical care more cost effective and increase patient safety. To make the delivery of care more time and resource efficient is not seen as a clinical necessity. A recent study shows that physicians meet interventions to reduce medical errors with caution [10]. CPOE is seen as effective by only 23% of physicians. The study also suggests that as socialization process medical education might be instrumental and can help adoption these interventions.

However, once physicians are using CPOE, they appropriate the system by developing order sets and thus using the system to save precious physician time. They are then mainly focused on their individual practices, and the next step of addressing the delivery of care at the hospital level is difficult to make. Physicians still poorly understand long-term benefits of improving patient care and therefore the need of changing medical work practices.

Change of communication patterns between nurses and physician is seen as the most important impact of CPOE. The problem seems to subside, as physicians get more experienced in using CPOE and find new ways of communicating with nurses.

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# CHAPTER 6

## Extending the understanding of computerized physician order entry: implications for professional collaboration, workflow and quality of care

Jos Aarts, Joan Ash, Marc Berg

### Summary

*Objective*
To describe the perceived effect of computerized physician order entry (CPOE) on professional collaboration, workflow and quality of care.

*Design*
Semi-structured interviews with experts involved in the design, implementation and evaluation of computerized physician order systems in the United States.

*Measurements*
The interview transcripts were analyzed using six key concepts that identify context, professional collaboration, workflow and quality of care. *Results*: The interviews reveal the complexity of CPOE. Although providers enter the orders, others collaborate in the decision making process. There is a profound impact on workflow beyond that of the provider. While quality of care is the main impetus for implementation, it remains terribly difficult to measure the impact on quality.

*Conclusions*
A proper understanding of CPOE as a collaborative effort and the transformation of the health care activities into integrated care programs requires an understanding of how orders are created and processed, how CPOE as part of an integrated system can support the workflow, and how risks affecting patient care can be identified and reduced, especially during hand-offs in the workflow.

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## 1. Introduction

Computerized physician order entry (CPOE) is defined as a process that allows a physician to enter medical orders directly and to manage the results of these orders. The concept is receiving an increasing level of attention because the Institute of Medicine notes that CPOE holds potential for decreasing the number of medical errors in health care organizations and recommends full-fledged implementation [1]. The Leapfrog Group - a coalition of over 150 public and private organizations providing health care benefits - has echoed this plea by recommending that hospitals introduce computer systems to computerize drug prescribing and that they be rewarded for it [2]. The California State Health and Safety Code, section 1339.63, requires the introduction of technology, such as CPOE, that has been shown effective in eliminating or substantially reducing medication-related errors, in all California hospitals by January 1, 2005.

In reality, the implementation of CPOE has been problematic. In a recent survey, Ash et al. found that less than 10% of the US hospitals have implemented CPOE, a figure even lower than the results of an earlier survey by the same authors [3, 4]. Several case studies describe how physicians have opposed CPOE for different reasons, such as the amount of time spent at the computer and concerns about clerical work that fall outside of their professional practice [5-8].

Order communication is a highly collaborative process. A case study by Goorman and Berg suggests that the notion of interdependence in work is a key feature in creating medical orders and that nurses play an active role in entering medical orders in computerized systems [9]. Gorman et al. contend that the model of health care delivery underpinning CPOE is too naïve and suggest a model of distributed cognition among professionals to understand the creation of medical orders in a collaborative environment [10]. In a study about communication among health care providers in the ICU Pronovost et al. found how a daily goals form—developed to improve a common understanding of the daily goals of therapy—was associated with improved patient outcomes [11].

High-level CPOE experts recognize the difficulties with getting CPOE systems to work in everyday health care settings. This paper reports results of interviews with these experts to combine their rich experience and insights with theoretical insights from medical sociology and the field of Computer Supported Cooperative Work (CSCW). The goal is to enhance the general understanding of CPOE implementation and use. More specifically, the notions of professional collaboration and workflow are core themes in this understanding. A proper understanding of these themes is a *sine qua non* to reap the full benefits of CPOE technology in health care work.

The experts have been selected from among attendees of a consensus panel meeting to identify principles for the successful implementation of CPOE; the first and second authors took part in this meeting [12].

## 2. Extending the understanding of CPOE

CPOE systems have primarily been designed with the tasks and responsibilities of individual physicians in mind and implementation efforts have been primarily targeted at them. Goorman and Berg, however, argue that the model underpinning CPOE contains a projection of medical activities that does not match the activities of physicians as they actually take place on a ward [9]. In their study of order creation, Gorman et al. also suggest that the implicit model underlying CPOE does not take account of its collaborative nature [10]. In these models, orders originate with a physician, who enters them into a system. Then the orders are transcribed and distributed to various departments, and are

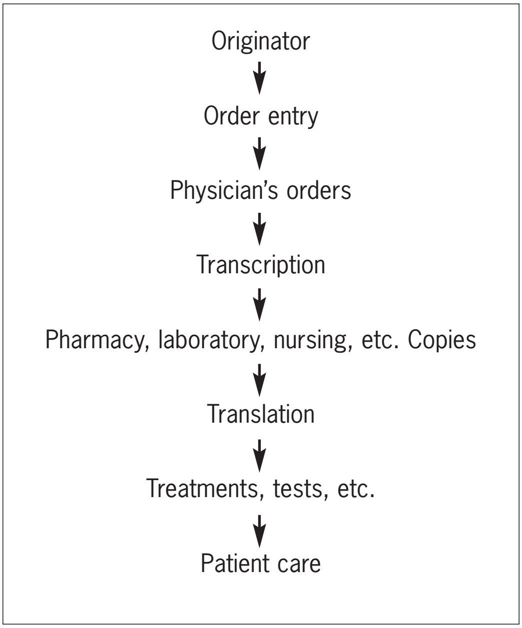


*Figure 1 - Processing of physician orders after Gorman. This is a very simplified, linear model that does not take account of complexity of the CPOE workflow. Much of the understanding of CPOE is directed on the order entry part. Each of the subsequent steps is less understood. Each of the hand-offs in the workflow is a potential source of errors.*

translated into executable functions such as lab tests, medications, treatments or other procedures. Health personnel then carry out these procedures that together comprise the patient care that is provided (see figure 1). Such views often simplistically present medical work as a fixed sequence of steps based on the rationality of the scientific method.

Many scholars have explored the collaborative nature of medical work. In a classic study Strauss et al. describe how the delivery of patient care can be characterized as managing a patient illness trajectory that includes the total organization of work done of over that course [13]. The authors contend that decisions about patient care are not made by a single individual but are the result of "negotiations" of health professionals, sometimes even including the patient and his/her family. They argue that this concept is necessary for a sociological understanding of illness management preventing the researchers from being confined by simplified models of medical work and workflow found in most medical textbooks. The authors base their concept on close observation of health care professionals through seeing, hearing, and interviewing. Berg builds on this understanding by arguing that systems design and implementation should take into account the fluidity of the process and the content of medical work [14]. He also argues that in practice, boundaries between tasks and roles of health professionals are not so tightly drawn.

Pratt et al. argue that medical work, because of its inherent collaborative nature, can benefit from design and implementation methodologies from the field of computer-supported cooperative work (CSCW) [15]. In the 1980s, CSCW emerged as an interdisciplinary field that examines how computer systems can be instrumental in reducing the complexity of coordinating cooperative activities, individually conducted and yet interdependent [16]. Østerlund found that seemingly inefficient practices of duplicating or reduplicating patient data in different documents (whether on paper or in the form of information systems) in a patient trajectory are in fact instrumental to coordinate medical work activities among different professionals [17]. From these findings emerges a picture of patient care that by its very nature is supported by collaborative work practices. CPOE as a collaborative effort is involves the notion that order creation and processing are a result of professionals, physicians, nurses, and the patient making collaborative decisions about patient care.

This study addresses the following research questions:

- What are the perceptions of high-level experts about professional collaboration and workflow and how they impact the quality of care?
- What are the implications of the findings for the understanding of CPOE?

### 2.1 Professional collaboration

Decisions about medical care are integral to managing patient trajectories and result from a process of often implicit negotiations among stakeholders, including the patient [13]. Knowledge about the patient's illness and treatment is distributed among the participants in the trajectory. Creating and processing medical orders result from the interaction of physicians, nurses, other health professionals and sometimes the patient managing a patient trajectory. In a landmark ethnographic study of navigation work on a US military vessel, Hutchins found how cognition is distributed across the members of the navigation team, how this distributed cognition is different from individual cognition, and how the meaning of messages pertaining to an understanding of the situation is negotiated among the members to achieve a navigation goal [18]. Hutchins argued that his findings are valid for any type of teamwork aiming at some common goal. Goorman and Berg described how in a Dutch hospital the implementers changed a CPOE system designed for physician medication order entry. By facilitating nursing input, they restored the distributed way of manual medication ordering in which these nurses had always played a pivotal role [9]. In a study about order creation and communication in an ICU, Hazlehurst et al. showed how complex the interactions and the flows of information between the actors are. They described the pivotal role of a secretary making sure that a medical order is carried out as desired [19]. The number of studies about the complexity of order creation and communication are still very limited, but the studies mentioned above suggest that the models of medical work underlying CPOE may be too focused on the individual cognition and behavior of clinicians. Order entry, rather, has to be conceptualized as the result of a process in which the distributed knowledge about a patient problem helps the group members to interactively achieve a common goal.

### 2.3 Workflow

In the routing of the medical order many different professionals are involved, including nurses, pharmacists, physiotherapists, radiologists and lab technicians. This routing includes the order creation and communication process, and also the processing of the order at the receiving end and the returning of the results of an order result. For example, a physician or a nurse may enter a medication order, but then a pharmacist will check the dose and process it and the order will be returned in the form of a medication sheet for the nurse and a prepared dose for dispensing to the patient. Similar routings can be identified for other types of medical orders, such a lab orders. Health IT applications such as CPOE systems will typically support such routings through conceptualizing these steps as part of a workflow: a linear sequence of circumscribed activities, to be executed by sharply identified agents, within which each activity creates necessary input for the next step in the workflow. Both the concepts of professional collaboration and workflow have the notion of the involvement of multiple individuals, but the first emphasizes the synchronous and interactive aspect of getting work done.

In a study about the effects of CPOE on ICU workflow, Cheng et al. showed how the actual workflow with many feedback loops deviates from the idealized workflow [20]. The authors found, for example, that nurses frequently conversed with physicians about medical orders and that a pharmacist modification often results in a second medication sheet printed at the nursing station. In addition, only parts of the medical order workflow are supported by CPOE systems. Other parts, such as drug dispensing by pharmacy and drug administration by nursing are often supported by systems that are sometimes connected to CPOE systems by interface protocols [21]. For example, automated drug dispensing cabinets containing tailored patient dosages are becoming more common. However, these machines are not always integrated with CPOE systems. This means that in the overall medical ordering routings, many hand-offs still pose a risk for the quality of the ordering process. In the words of Brown and Duguid, workflow in health care is not a linear, step-by-step process with clear-cut inputs and outputs and sharply targeted information needs. Rather, in health care, the 'workflows' require many interactions between the activities and their "owners" that in reality are not sharply demarcated at all [22].

### *2.3 Quality of care*

Implementation of CPOE has been recommended to reduce medical errors and increase the quality of care [23]. Evaluation studies of CPOE implementation in hospitals in the 70's and 80's showed economic savings and also better patient outcomes in terms of reduction in length of patient stay and improvement of the quality of medication orders in terms of legibility, completeness and decrease of transcription errors [24]. Later studies were fully focused on medication errors and adverse drug events. Kaushal et al. reviewed the effects of CPOE and clinical decision support systems on medication safety and concluded that CPOE significantly decreased medication error rates [25]. But the evidence is based on a limited set of clinical studies (two controlled trial studies, two observational studies with controls and one study that employed both designs). Much less is known about medical errors throughout the entire workflow process, but a study by Berman suggests that most medical errors occur during dispensing (53%), administration (24%) and then prescribing (15%) [26]. Several strategies have been recommended to reduce errors, such as the use of bar coding technology and automated dispensing systems [27]. However, Oren et al. show that the evidence that these technologies reduce medical errors and adverse drug events is very limited [28]. Reason et al. point out that there is a risk that technological solutions to increase patient safety may be focused too much on individual behavior and they may ignore organizational behavior [29]. Several studies suggest that physicians in particular are not aware of the systemic nature and size of the problem [30]. There is anecdotal evidence that physicians often blame each other about making mistakes and assert that it does not apply to them. Also, many errors are corrected in the workflow without the ordering physician becoming aware of it.

The issues raised in the three previous paragraphs suggest that efforts to improve patient safety and the quality of care should also focus on occasions that may disrupt the fine fabric of professional collaboration and the workflow involving many different professionals.

## 3. Research methods

To extend the general understanding of CPOE, this research focused on the perceptions of experts about professional collaboration, workflow and quality of care. In October and November, 2003, the first author conducted 16 semi-structured interviews with 17 experts involved in CPOE implementations (see table 1). The experts were partly selected from the participants in the first consensus meeting on the successful implementation of CPOE in which the first and second authors participated [31]. The interviewees represented users, implementers, vendors and researchers. The first author also visited a community hospital that has been using CPOE for many years and interviewed an IT project leader, a hospital management executive, and two physicians together. In all, the interviewees represented 12 different organizations, which included five academic medical centers, three community hospitals, a VA medical center, a health maintenance organization, and a vendor. The high level of knowledge of the interviewees offered the authors an opportunity to explore CPOE issues in-depth.

The duration of the interviews varied from 30 minutes to one hour and 15 minutes and lasted on average 50 minutes. The respondents received by e-mail a brief note that explained the purpose of the study and listed six topics that would be addressed during the interview. They were:

- The description of the CPOE system in use and history of the implementation.
- The users of CPOE and their involvement.
- Organizational impact on medical work.

| Interview no. | Interviewed person | When | Role in CPOE | Affiliation | Key topics of interview |
|---|---|---|---|---|---|
| 1 | Physician | Oct 2003 | Medical director clinical information system | Community hospital chain | CPOE implementation strategy in non-teaching hospital setting; physician role |
| 2 | Physician | Oct 2003 | Medical director clinical information system | Health maintenance organization | Implementing strategy of CPOE; quality systems |
| 3 | Physician | Oct 2003 | User, researcher | Health maintenance organization | User perspective of CPOE |
| 4 | Medical informatics scientist | Oct 2003 | Researcher; director of applied research | Health maintenance organization | Research on CPOE; design strategies |
| 5 | Pharmacist | Oct 2003 | Pharmacist, implementer | Community hospital chain | Pilot implementation CPOE; pharmacist's role; back end of CPOE workflow |
| 6 | Nurse | Oct 2003 | Project leader CPOE implementation | Community hospital chain | Pilot implementation strategy in non-teaching hospital setting; physician role |
| 7 | Software specialist | Oct 2003 | Software designer CPOE | Vendor | CPOE product development; customer relations |
| 8 | Physician | Oct 2003 | Medical staff leader information systems | Academic medical center | Implementation strategy |
| 9 | Physician | Nov 2003 | Project leader medical record system, user | VA medical center | Implementation strategy; user support |
| 10 | Hospital managemant executive | Nov 2003 | Chief information officer | Community hospital | Health care strategy; IT strategy, CPOE implementation strategy |
| 11 | Two physicians (double interview) | Nov 2003 | User (hospitalist) developer, implementer | Community hospital | Use of CPOE; user support; implementation |
| 12 | Nurse | Nov 2003 | Coordinator CPOE | Community hospital | Development; user support |
| 13 | Physician; associate professor | Nov 2003 | Clinical researcher, medical user | Academic medical center | Decision support associated with CPOE; research on outcomes of CPOE and medical errors, quality systems |
| 14 | Physician; assistant professor | Nov 2003 | Researcher, teacher | Academic medical center | User perspective of CPOE |
| 15 | Physician | Nov 2003 | Quality informatics director | Academic medical center | Decision support associated with CPOE; research on outcomes of CPOE and medical errors; quality systems |
| 16 | Physician | Nov 2003 | Researcher | Academic medical center, research institute | Design, implementation and use of CPOE; research on decision support |

*Table 1 - List of interviews conducted with 17 experts involved in CPOE. The experts included participants of the first consensus meeting on meeting on the successful implementation of CPOE systems and staff members of a community hospital and consisted of 11 physicians, 2 nurses, 1 pharmacist, 1 hospital executive, 1 medical informatics researcher and 1 software specialist. The interviewed persons represented 12 organizations (see table 2). In each of the interviews the six domains (see text) were addressed. Depending on the expertise and experience of the interviewed person certain topics were emphasized. The key interview topics are listed in the last column.*

- Redesign of the CPOE workflow.
- Patterns of collaboration at order creation.
- Effects on quality of care.

The first three topics were meant to provide the context of the involvement of respondents with CPOE systems. The last three topics were central to the research questions.

Details about the interviewed experts, their backgrounds and key topics discussed are listed in table 1. The interview transcripts were analyzed with the help of Atlas 4ti, a software application for qualitative text analysis, using the last three topics listed above as units of analysis.

The study was approved by the Institutional Review Board of Oregon Health & Science University as part of the "Physician Order Entry: Field Study of Success Factors (National Library of Medicine grant LM06942-02)."

## 4. Results

The interviews resulted in 269 typewritten pages (single line spacing, A4 paper format). We will now briefly highlight some findings from the interviews focusing on context, professional collaboration, workflow and quality of care. The context encompasses the first three interview topics; and they are not listed separately. Organizations described in this section are those associated with the interviewees (see table 2).

## 5. Context

All university medical centers represented by these interviewees have implemented CPOE systems that have been in place for about a decade. One community hospital has had a CPOE system operational for three decades. The other community hospitals are planning to implement CPOE, have contracted with a vendor, and are already conducting pilots. The VA medical center and the health maintenance organization in this study have implemented CPOE as an integral part of their electronic patient record systems. The vendor represented by an interviewee has a large installed base of clerical and clinical systems, but its CPOE product is operational in less than ten hospitals. Two academic medical centers represented here have developed a strong research base for CPOE related clinical outcome studies. The main characteristics of the organi-

| Organi-zation no. | Interview no. (see table 1) | Type of organization | CPOE system | Physician employment status | Physician use | Main characteristics |
|---|---|---|---|---|---|---|
| 1 | 1 | Community hospital chain | Vendor system | Self-employed, hospitalists employed | Physicians involved in planning and pilot | Planning and pilot phase |
| 2 | 2,3,4 | Health maintenance organization | Vendor system | Employed | Full physician use | CPOE part of integrated medical record system |
| 3 | 5 | Community hospital chain | Vendor system | Self-employed, hospitalists employed | Physicians involved in planning and pilot | Planning and pilot phase |
| 4 | 6 | Community hospital chain | Vendor system | Self-employed, hospitalists employed | Physicians involved in planning and pilot | Planning and pilot phase |
| 5 | 7 | Vendor | Array of products, including clinical applications | Not applicable | | Several CPOE sustems fully implemented in hospitals, phasing into new product line |
| 6 | 8 | Academical medical centre | CPOE planned for the future | Employed | Not yet applicable; physicians involved in planning and pilot | Medical director of information systems has strong CPOE experience |
| 7 | 9 | VA medical centre | Vendor system | Employed | Full physician use | CPOE system part of integrated com-puterized patient record system |
| 8 | 10,11,12 | Community hospital | Vendor system | Self-employed, hospitalists employed | Full physician use | Current system being phased out and placed out and replaced by state-of-the-art system of same vendor |
| 9 | 13 | Academical medical centre | Homegrown system | Employed | Use by residents and house staff | Strong research base |
| 10 | 14 | Academical medical centre | Vendor system | Employed | Use by residents and house staff | |
| 11 | 15 | Academical medical centre | Vendor system | Employed | Use by residents and house staff | |
| 12 | 16 | Academical medical centre | Homegrown system | Employed | Use by residents and house staff | Strong research base |

*Table 2 - Main characteristics of the organizations of the interviewed persons. Most hospital organizations have implemented fully functional CPOE systems. Three community hospital chains are planning for such systems and are conducting small-scale pilots.*

zations are listed in table 2.

Though one community hospital, the VA medical center, and the health maintenance organization have acquired widely available systems, their involvement with the design and implementation was such that these systems were essentially homegrown. The users and system designers collaborated intensively on location to develop and improve the CPOE system. All respondents from organizations using CPOE indicated that implementation lead times are on the order of three years or more up to the moment that a substantial number of physicians are using it. All implemented systems have the order entry piece; few of them are really integrated into comprehensive systems that cover the complete workflow including pharmacy and drug dispensing. The implementation of CPOE is seen by all as quite complex.

The respondents from organizations that have implemented CPOE all mention a high degree of physician use. None of them, at the time of the interviews, had made CPOE use mandatory, but they created conditions that left physicians very little choice. For example, the medical director of the health maintenance organization explains that over 95% of the physicians do order entry because of a policy that only physicians can sign off medical orders: “It is not a written policy [to do computerized order entry], but it is the general policy.”

The community hospitals that are planning to implement CPOE systems cannot be so sure that physicians will enter their own orders electronically. The interviewees from these hospitals fear that physicians will consider such a task as clerical and they emphasize their prudent methods for involving them. Their physicians are not employed by the hospitals, but they have, as part of large medical groups, agreements to send their patients to the hospital. If they are unhappy with one hospital, they can sometimes send their patients relatively easily to another. The CPOE project leaders focus on physicians who can be considered as early adopters and they try to identify immediate benefits for them—such as making their workflow more efficient and appealing to their pride in providing quality care—and by trying not to upset them by making CPOE use mandatory. They expect that peer pressure will bring other physicians on board. Nurses are often much more involved in the medical ordering process than physicians are. In these hospitals, nurses are very involved in handling medical orders, sometimes guided by clinical protocols and guidelines. Even so, CPOE pilots are placing the physician in the foreground. In teaching hospitals, which include the academic medical centers and the VA medical center, it is common to delegate medical order entry work to house officers. Entering medical orders is seen as part of their training. It is much more difficult to do that in community hospitals, which usually do not employ residents.

In order to increase physician use of CPOE, the community hospitals are seeking to involve hospitalists who are employed as primary care physicians or internists by the hospital or the contracted medical group. In the hospital they take routine care on a 24-hour basis of the patients sent in by private physicians. After explaining the pilot test in a rehabilitation unit, a medical director of clinical information systems in a community hospital describes the implementation strategy this way: “So after we do rehab, we’re gonna go after the hospitalists. And the hospitalists are internists that are paid by the hospital, so they’re hospital employees. Then we’re gonna go after the house staff. They’re residents. Then we’re gonna start rounding with private physician groups one by one, but by then we’ll have the house staff and the residents on it, so if it hasn’t worked for the hospitalists and the residents then we pull the cord on the project. If it has worked for them, then we can use them to sell it to the other physicians.” The medical group associated with the community hospital that is known for its high physician involvement in CPOE employs hospitalists for taking a care of the hospitalized patients belonging to the group, and they thus accept a large part of the burden of doing order entry.

The respondents in the organizations that have implemented CPOE all indicated that physicians have made electronic order entry part of their work life and found it hard to compare with the situation before. However, ongoing changes in the CPOE system may still affect medical work practices. For example, in the health maintenance organization, workstations are now being installed in the exam rooms. Up to this point, order entry would take place in the physician’s office after the patient had been seen. The physician would take notes on a piece of paper and then bring that to his office and do the order entry. Taking notes and rereading gives the physician the opportunity to reconsider his decision-making and alter his decisions if necessary. Introducing the workstation in the exam room would allow immediate order entry if this fits the physician’s individual workflow.

### *4.1 Professional collaboration*

None of the interviewees from institutions that have implemented CPOE described explicitly the problem of the complex decision-making that precedes order entry. There is nevertheless a distinction between the stage before entering the order, during which people interact and decide what to do, and the act of entering the order itself. The physician enters the order because he or she is best able to appreciate and interpret the suggestions of the associated decision support system.

For the respondents who are implementing CPOE in community hospitals, the explicit and implicit roles that nurses play in creating orders are an issue. When preparing a CPOE pilot in a hospice unit of a community hospital, the project pharmacist found that nurses and physicians had developed ways of working with pain medication orders that allowed liberal bounds for dosing. It was perhaps the small size of the group which made "everyone comfortable with each other's work and therefore [they] had a pretty liberal, had a lot of leeway to do what they felt was necessary for the care of the patients." He observed that it turned out that it was difficult to use the structured format that computer entry really requires.

The chief information officer of a community hospital, on the other hand,expects that CPOE will facilitate the introduction of clinical paths, for cardiology for example, and that having clinical paths will require more explicit collaboration between physicians and nurses and that their collaboration will be supported by clinical guidelines and protocols.

### *4.2 Workflow*

The respondents all agree that redesign of the workflow needs to be addressed more adequately. Most of the work on CPOE was until recently mostly focused on the order entry part and the associated decision support because of the intrinsic complexity of implementation. A clinical researcher of a teaching hospital that has implemented CPOE comments that "CPOE is a big project, and doing each of the back end links is quite time consuming. So it is not an unreasonable approach to do things, for example, just to put in the front-end and perhaps put in a little link to pharmacy and then to say that we are gonna go back later and do the links to the other ancillaries later on." A director of quality informatics who has been involved in CPOE implementation projects in other academic medical centers acknowledges that "many people even in a sophisticated health care institution think explicitly about what are the processes, you know, the fact that there is a decision making process, and that the physicians execute their orders and then the nurses take off their orders and some of those things get routed to the lab and some of those things get routed to pharmacy and some of these things get routed to radiology and then the radiologists take over, and that, if you wanted to improve something you would target various aspects of that process."

Three issues emerged. First, there is the possible lack of understanding in hospitals about how IT relates to workflow. The software specialist reported a case in which a hospital wanted to have CPOE in first and then add charting, ignoring that orders might get lost because nurses would have no way of knowing whether an order was in. She suggested a careful rethinking of each step in the workflow, assessing what technology would need to come first and then deciding about CPOE before it becomes the "dark ordering side of the loop."

Second, there is a concern how the roles of the participants in the workflow would change. The same software specialist reported a case of a communication breakdown in which, after implementation of CPOE, nurses were not informed about orders and could not initiate interventions because the doctors entered all orders themselves. The project pharmacist reported the role of the pharmacist in verifying orders. In most CPOE implementations, the pharmacist would still verify orders and get back to the physician if he felt that the order was incorrect or inappropriate. Introducing advanced decision support in CPOE might reduce the role of pharmacist to mere dispensing. However, the pharmacist's role might actually become broader. According to the project pharmacist: " … but also at a more general sense being able to look at the entire picture and see if there are some omissions to a patient therapy or if some therapies appear to be redundant, you know, and that's a more of a bigger picture role. And there have been several publications in the last few years about the value of pharmacists in patient rounds, ICU rounds; I think that's a role that they are going to be transitioning in to as POE continues to roll out."

The third issue concerns the notification process. Before CPOE implementation, nurses would know about medication for patients before the order went to the pharmacy and they could start to prepare for dispensing almost immediately. A CPOE project leader summarizes the problem: "So one of the big hurdles that we are trying to identify and meet is this sort of new order notification process. How does the nurse know, or anybody know, when there are new orders in the system. Currently, they are written, the nurse actually or the ward clerk or unit secretary actually enters them into the computer, so that is when they know. If it is CPOE, the physician can either be entering those orders in on the unit, they could be on another unit, they could be in their office or indeed they can be at home, entering an order. So, that whole new order notification process is a big change with CPOE, and we have done things to get the nurses with a sort of electronic notification, electronic alerts to counteract that sort of thing."

### *4.3 Quality of care*

The positive effects of CPOE on reducing medication errors, publicity about the IOM reports on patient safety, and the subsequent stream of reports by consulting firms about the necessity of CPOE and the current level of implementation, were the most important reasons why hospitals implement CPOE. They recognize that the number of scientific studies is limited and that the results of the Brigham and Women's Hospital and Regenstrief Institute studies are hard to extrapolate because of the poor replicability. However, as the hospital executive noted: "Key to us is patient safety initiatives."

Apart from the respondents from the academic research institutions, none of the respondents who had implemented CPOE had any direct proof of improved quality of care. In the health maintenance organization and the Veterans Affairs medical center implementations of CPOE systems, the quality of care was very much associated with their preventive medicine and public health emphases. Because the orders become part of the electronic medical record, the physicians were able to flag patients for check-ups and special treatments. According to interviewees, this integrated functionality improves patient outcomes.

## 5. Discussion

Not surprisingly, several dimensions of complexity of CPOE implementation and use emerges from the interviews. First, implementation is a thoroughly social process in which the roles and responsibilities of health professionals are changing. Second, CPOE needs to fit the workflow, which is not always well understood. Third, evidence of a positive impact on the quality of care is still limited. The results of this study are consistent with theoretical insights from the sociology of medical work and the design of systems supporting collaborative work.

### *5.1 Professional collaboration*

The role of the physician is key to CPOE implementation because the physician is expected to be responsible for entering orders. Implementation efforts focus on strategies for involving physicians. In the academic medical centers, house officers (residents and fellows) enter orders as part of their training, supervised by their superiors. Another strategy is to design system features in such a way that they are only useful for physicians. The major concern about physicians interacting with CPOE systems is that they take additional time, confirmed in a study by Doolan and Bates [32]. Many efforts are therefore made to adapt the system such that physicians can do the task faster or that the value of the information they get from the system compensates for time lost. Respondents from community hospitals that are planning to implement CPOE systems want to maintain good working relationships with self-employed community physicians. They are concerned about the future role of nurses who entered medical orders on behalf of physicians. There is a trend toward hiring more hospitalists—primary care physicians and internists who are employed by medical groups or hospitals to take care of patients in the hospital on a 24/7 basis. Hospitalists seem to do most of the computerized order entry tasks and, like house officers, they are employees, so their use of CPOE can be mandated. A review of the hospitalist movement estimates that currently 7,000 hospitalists are employed in community hospitals across the United States and that their number will grow to 19,000 [33]. One can infer from these figures that hospitalists will play a key role in CPOE, and will ease the problem of involving self-employed physicians.

The growing shortage of health care personnel will probably also increase the need for delegating tasks, including drug order entry, to highly qualified professionals such as nurse practitioners. In the UK, specialized nurses are authorized to prescribe drugs in defined circumstances using a tailored formulary and special guidelines and protocols [34].

The observations of the respondents parallel findings of Strauss et al. that patient care can be characterized as group work [13]. Gorman et al. concludes from a study of physician order entry in critical care that an approach focused on the outcome of the medical decision and the entering of the order in the system ignores the complexity of group work in which the medical order comes into existence [10]. According to Gorman et al., group work appears to facilitate sense making and involves mutual construction of understandings over time. Despite the focus on physicians' use computerized order entry, different professions are very much involved as well. While in teaching hospitals the burden of order entry is carried by residents and house staff, an increasing number of hospitalists fulfill a similar function. This tendency will probably not change the group work and nurse's role that is so essential in creating orders. A proper understanding of CPOE in different health care settings requires an understanding of order creation as a complex professional collaborative process at the point of care.

### *5.2 Workflow*

A narrow focus on order entry results in both an overly linear and also fragmented view of the workflow. The problems are threefold. First, and closely tied to the previous point about professional collaboration, the roles, tasks and responsibilities of different professionals are in practice much less clearly circumscribed than they are taken to be by many system designers [22]. Second, changes in these roles, tasks and responsibilities of different professionals remain mostly implicit and not clarified. For example, when decision support becomes an integral part of CPOE, will the role of the pharmacist be reduced to merely dispensing the drugs? Or when the pharmacist has a key role in assuring the quality of medication ordering, how will that affect workflow? Or should the role shift towards counseling the physician, helping to develop guidelines and protocols, and taking part in clinical rounds? Before introduction of CPOE, the nurse would often know immediately that an order was being written. Now the nurse needs to be notified electronically, which raises the questions about when that will happen and how that will happen. From the interviews a picture emerges that many solutions to these problems are quite ad-hoc. Third, many different information systems that are not integrated support parts of the CPOE workflow. For example, when a medication order arrives in the pharmacy, it may be entered and verified in a system that is not connected to the order entry system, and the medication might then be packaged with a barcode label and processed in a different system for dispensing.

The IOM report envisages a health care system that supports continued improvement in the six aims of safety, effectiveness, patient-centeredness, timeliness, efficiency and equity [23]. The services in such a system are "coordinated across practices, settings, and patient conditions over time using increasingly sophisticated information systems." In this vision CPOE should be part of an integrated IT system fully supporting the continuum of care. This requires a transformation of the delivery care system into care programs with measurable outcomes, integrated planning, restructuring and delegation of tasks, and IT supporting the process of care. As a hospital executive observed: "Other industries would never allow the fragmentation to occur that occurs in health care. The automotive industry, the finance, I mean, they just, it is all about consolidation and dis-intermediating all that crap from happening, right? We have allowed intermediations and hand-offs to happen, and quite frankly, when you think about it, that is why health care doesn't deliver at the level that it can. Every hand-off is an opportunity for failure."

### *5.3 Quality of care*

Research on the benefits of CPOE in preventing medical errors has mainly been focused on the order entry piece and on the individual behavior of the physician. All respondents quote these studies and the recommendations of the IOM and interested groups such as the Leapfrog Group as the main reason to implement CPOE and expect that their organizations will see dramatic improvements in the quality of care. According to Bates et al., the benefits of CPOE derive for the most part from physicians interacting with decision support [35]. The studies, however, seem to ignore the collaborative nature of health care work and the fact that order entry is part of a complex workflow. According to Hutchins, many errors in group work are corrected through the interactions of the actors and group performance seems to protect against errors or failures of individual members [18]. Hutchins argues further that the individual response to errors results from mutual learning, allowing newcomers to adopt explicit and implicit rules set in the group. These findings imply that similar mechanisms should be found in health care work when it is seen as a collaborative effort. The question needs to be asked whether and how computerized decision support will be able to substitute for the safety network that characterizes current practices of creating and entering orders collaboratively.

While at the point of creating and entering orders the synchronous characteristic of professional collaboration may be important, Hutchins' arguments also holds true when considering workflow, where time sequential, asynchronous activities across organizational boundaries (within or outside a hospital) are dominant. The use of different information technologies in the workflow such as order entry systems, pharmacy systems, and dispensing systems adds another degree of complexity that can be a serious source of errors and failures. Analyzing the workflow to reduce errors and improve the quality of care can lead to the next step of rethinking the workflow. According to Groth, the revolutionary impact of IT is that it makes possible new coordination mechanisms and thereby new forms of organization [36]. The interviewees from the health maintenance organization described how their information system enabled them to design targeted programs for patients with specific health problems such as diabetes. The information system, which is an integration of an electronic medical record and a physician order entry system, allows identification of patients who have been diagnosed with, for example, diabetes, use of order sets and assessment of disease specific outcomes. Introducing CPOE requires integration not only at the system level, but also at the level of patient care. The example of the health maintenance organization shows how the integrated approach allows a change from order management that centers around order creating, processing and retrieving results to program management in which activities are planned, integrated and organized towards disease profiled patients. The next step then for improving quality is to create care pathways, to examine the roles are of the actors in the pathways, and to assess how CPOE might fit into such concept.

### *5.4 Limitations of the study*

This study has several limitations. First, the selection of experts may be biased because they were chosen from among the participants of an invitational consensus meeting. However, the potential for bias was minimized because of the variety of their professional backgrounds and their organizations and because the semi-structured format of the interview was consistent in all interviews. Second, the data obtained about CPOE were largely self-reported, although the contents were verified by comparing data from multiple sources.

## 6. Conclusion

The interviews show a rich picture of CPOE that includes practical issues of use and implementation and policy issues related to organizational strategy and changing health care practices. The interviewees acknowledge the complexity of integrating those issues into a comprehensive approach. But the next step might require the abandonment of accepted truths, such as the belief that only a licensed physician can enter orders and that this will therefore increase patient care quality. As one informant noted, if you focus on a subatomic task to increase patient safety you may well decrease patient safety in the overall process of care. For example, the current uncertainty about introducing CPOE in community hospitals could be turned into strength if hospitals and medical groups work together to create patient care pathways across organizational boundaries and examine how information technology might fit in such a concept for increasing the quality of care. An increasing number of hospitalists are being hired to provide the continuity of care and they are becoming instrumental in the implementation of CPOE.

Extending the understanding of CPOE then translates in an understanding of care pathways and addressing the question how CPOE might fit into such a model. Care pathways can be analyzed through observational methods. Insights from CSCW may help to design and implement CPOE in a collaborative environment.

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# CONCLUSION

The introduction of an information system in health care practices is a thoroughly social process in which both the technology and the practice are transformed. That is the general conclusion of this thesis. Such a broad conclusion could easily provoke the reaction: "So what?" Let me draw upon the conclusions of the research described in the previous chapters to make this general conclusion more specific.

The basic assumption in chapter 1 is that an implementation process can be characterized by stages and that this process is in continuous interaction with the health care environment in which the information system is implemented. These stages are not clear-cut in the sense that they have defined inputs and outputs or that they can be strictly delineated. Rather, the stages help to identify appropriate activities to implement a system. The implementation process interacts with the health system, or more precisely, with health care work. A health care organization is centered on health care work. It facilitates and constrains what health care workers can do. The interaction has an ethnographic connotation in the sense that a change manager has to interact with health care work to understand how an information system might fit. She needs not just to ask, but also to observe, to enquire, to respond, etc., in the sense that Marc Berg describes as essential for a sociotechnical approach, a detailed, on-site insight of work practices [1].

Chapter 2 addressed the question how the outcomes of the implementation of a CPOE system can be explained from a sociotechnical perspective. A sociotechnical approach stresses the importance of the intertwinement of technology and its social environment and suggests a variety of aspects to explore this intertwinement. The chapter presented a detailed account of the implementation of a CPOE system in Radboud University Medical Center from the moment when there was a perceived need to acquire a clinically focused information system until 12 years later when the implementation of the core functionality of physician order entry was abandoned. The case study showed the clash between the rationality of the system expressed in technical and functional specifications and its actual use. The new system did not require a keyboard and memorization of command keys and the implementers thought that the new system would be easier to use. The opposite happened: the system slowed down the users and more personnel needed to be hired to cover the workload. This was quite contrary to expectations. I introduced then the concept of 'fit,' a match between the requirements of work practices and the capabilities of the system. I argued that 'fit' is not an intrinsic property of the technology or a work practice, but needs to be created. 'Fit' is the *result* of a process in which both work practices and technology change. Indeed, users have to change the way they work. In similar fashion a system will not behave as it often was intended. People will tinker with the system to make some tasks easier or more efficient. For example, the CPOE system was originally designed for American-style inpatient clinical work and had to be adapted for the typical Dutch "ambulatory clinic" emphasis in hospital work. The case showed also that time was a crucial element. Decisions about the technology that made perfectly sense at the beginning of the project were constraining in hindsight. In the early 90's people were used to keyboards and character based screens. When the system was activated users were already acquainted with Windows-based applications and a mouse as an interaction device. The screen design of the information system looked very outdated. It was very similar to how WordPerfect was ousted by Microsoft Word. The point is that this change could not be predicted. It didn't happen suddenly; it emerged as a new technology penetrated the market. Using Wanda Orlikowski's terminology I labeled this phenomenon as emergent change [2]. The challenge is not to predict change, but how to respond to it. Fox example, the mainframe based CPOE system was emulated on a PC's while it retained the character-based look and feel. The designers could have considered not only the emulation of the system itself, but also of a Windows look-and-feel. Finally, the case showed how closely technology and organization were connected. Often users assume that introducing a new system means that also new computer technology will be installed. However, the installed computer hardware and its technical infrastructure constrained the choice for a new system. The choice was limited to systems that could run on the existing computer mainframe. It was not only an issue of just some pieces of hardware. Complex hardware requires expertise for development and maintenance and expertise is not easily exchangeable.

In chapter 3 I addressed the different outcomes of the implementation of CPOE systems in Radboud University Medical Center and Atrium Medical Center in Heerlen. Contrary to Radboud, Atrium implemented the full functionality of order entry, but the hospitals had in common that physicians stayed out of the loop. I explained the difference by looking closely at the nature of medical work practices. I argued that users were more interested to know how their work would change because of the system than to know what the system would look like. It is the acceptance of the change of work practices that is crucial for the acceptance of an information system. I also argued that medical work practices and professions are less tightly coupled then one would expect. Physicians considered electronic order entry as not belonging to their professional domain, but the nurses and secretaries saw entering orders as an extension of what they already did; they therefore made the CPOE system part of their work practices.

Chapter 4 and 5 described the comparison of CPOE implementation strategy of three hospitals in the Netherlands and three in the United States. I compared the implementation on ten aspects and found that the differences between the Netherlands and the United States were not substantial. All hospitals cited the need to save costs and increase efficiency of health care delivery as the main reasons to implement CPOE. Even in project management where American leadership could be posited against Dutch negotiating and compromising, the difference was more gradual than absolute. However, all implementations took a minimum of five years to complete. Apparently this long time is intrinsic to any implementation of a complex information system. Hospital executives should therefore not count on swift results and rapid return on investments, but rather plan for long implementation lead times and take into account the uncertainty that is part of it. The implementations were mainly management driven and did not meet perceived clinical needs of the physicians. However, once physicians started using the system they tried to make the system more efficient. Instead of entering each order separately they combined orders into order sets for types of patients that they see often. They considered order sets far more efficient than handwriting orders. I suggested that their clinical expertise helped them to increase the sophistication of use and allowed them to appropriate the system. This kind of improvised improvement is what Claudio Ciborra calls ‘bricolage;’ it is not really planned, it helped them to appropriate the system, but it still innovative [3]. In Atrium nurses and secretaries entered orders electronically as a proxy for physicians, but their lack of clinical expertise prevented the development of order sets.

Chapter 6, finally, aimed to extend the understanding of CPOE to include professional collaboration and workflow and see how CPOE impacts the quality of care. Here I argued that order communication is a highly collaborative process. An apparently simple process such as prescribing medication for a patient is the result of physicians and nurses talking to each other and exchanging viewpoints, which ultimately leads to a decision. And that decision is entered as a drug order. CPOE systems have primarily been designed with the tasks and responsibilities of a physician in mind, and therefore a potential conflict can arise between the system and its use. Moreover, medication ordering is part of a workflow in which an order is received and processed by a pharmacist and sent back in the form of a medication and a drug dosage to be administered to the patient by the nurse. Interviewed CPOE experts acknowledged the complexity of getting such systems to work in a clinical environment. A proper understanding of CPOE as a collaborative effort requires an understanding of how orders are created and processed, how CPOE as part of an integrated system can support the workflow, and how risks affecting patient care can be identified and reduced, especially when the order moves from one professional to another.

Coming back to the general conclusion, the study shows how work practices change, for example when physicians develop order sets to make their prescribing work a little easier to do. Technology changes also, if only because new functionality is added. That is a social process. The changes are not easily predictable. That is a predicament for an implementer. Maybe she would to like to design a system according to blueprints and to plan systematically its deployment. But Claudio Ciborra advises her to make organizational improvisation part of the implementation process, to allow prospective users to tinker with the system and let them find ways of working that suits them best, plan for the unexpected and value emerging practices and give up strict control [3]. The generalization is situated in the principle, not in the predictability of individual cases.

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# SAMENVATTING

"Het is gemakkelijker om een mens naar de maan te lanceren dan een ziekenhuis informatiesysteem te implementeren," schrijft Morris Collen in zijn boek over de geschiedenis van de medische informatica in de Verenigde Staten [1]. Dit ene zinnetje illustreert treffend hoe moeilijk het is om in een ziekenhuis een informatiesysteem in te voeren. Het ziekenhuis wordt door Collen omschreven als de "meest complexe organisatie die ooit door mensen is bedacht."

Organisatieverandering is kenmerkend voor de implementatie van informatiesystemen. Niet altijd zijn het veranderingen ten goede; vaak presteert een organisatie slechter nadat er een systeem is geïmplementeerd. Snel wordt dan geconcludeerd dat het systeem op een of andere manier slecht is ontworpen. In 1975, toen het ontwerpen en bedienen van informatiesystemen vooral werden gezien als een technische activiteit, schreef Henry C. Lucas al over falende systemen: "Onze ervaring doet echter vermoeden dat de voornaamste oorzaak van het mislukken van informatiesystemen gezocht moet worden in het gedrag van organisaties [2]." Dertig jaar onderzoek heeft geleid tot een toename van de kennis van informatiesystemen in de context van organisaties, maar de lijst van succesvolle implementaties is heel beperkt. Een zorginformatiesysteem is bijzonder moeilijk te implementeren omdat het niet alleen de organisatie als geheel beïnvloedt, maar ook het werk van zorgprofessionals die hun professionele autonomie koesteren.

De toenmalige directeur Staf Zorg van het UMC St Radboud te Nijmegen stelde in de zomer van 1997 het onderzoek voor dat beschreven wordt in dit proefschrift. Hij vroeg mij of ik belangstelling had hun nieuwe ziekenhuisinformatiesysteem te bestuderen. Hij beschreef het systeem als een geautomatiseerd ordercommunicatiesysteem dat artsen in staat zou stellen hun medische orders in te voeren. Het projectteam dat verantwoordelijk was voor de implementatie kon wel enige feedback gebruiken en hij dacht dat het wel een goed onderwerp zou zijn voor een proefschrift. Ik zag een unieke kans om de geschiedenis van een systeem te documenteren vanaf het eerste begin van de ontwikkeling tot de volledige ingebruikname. Het was een belangwekkend systeem omdat het gericht was op het medisch handelen in tegenstelling tot andere ziekenhuisinformatiesystemen die voornamelijk voor administratieve doeleinden waren ontworpen. Het ingewikkelde project zou uiteindelijk 5000 professionals inclusief artsen aangaan. In het begin leek de implementatie voorspoedig te verlopen en waren er geen voortekenen van de mislukking die twee jaar later zou blijken.

Deze studie gaat over implementatie en over informatiesystemen die de zorg ondersteunen. Implementatie bestrijkt het invoeringstraject van een informatiesysteem vanaf het moment dat het nodig wordt gevonden om een orga nisatieprobleem aan te pakken tot het gebruik in werkpraktijken. Om de uitkomst van een implementatietraject te kunnen begrijpen moet men teruggaan in de geschiedenis om belangrijke gebeurtenissen te identificeren die de richting van het traject hebben beïnvloed en in de tijd volgen hoe de informatietechnologie werd ingevoerd en geïnstalleerd.

Zorginformatiesystemen zoals elektronische patiëntdossiers zijn bedoeld om de toenemende informatiebehoefte van zorgverleners en de uitvoering en coördinatie hun werkzaamheden te ondersteunen.

Deze studie gaat het in bijzonder over geautomatiseerde ordercommunicatie systemen. Ordercommunicatie systemen stellen een zorgprofessional in staat om medische orders elektronisch in te voeren en na een verloop van tijd het resultaat ervan te zien. Medische orders vormen een sleutel in de zorgverlening in de zin dat zij het resultaat zijn van medische beslissingen. Bijvoorbeeld, wanneer in een ziekenhuis een arts vindt dat een patiënt behandeld moet worden met een geneesmiddel, schrijft zij een medicatieopdracht. De opdracht of order wordt ontvangen door de apotheek. De apotheek controleert de order, maakt een medicatielijst en prepareert en verpakt het geneesmiddel. De verpleegkundige dient tenslotte het geneesmiddel toe aan de patiënt. Door middel van een ordercommunicatie systeem kan de arts een opdracht direct in de computer invoeren en daardoor vervalt de noodzaak om een briefje te schrijven en de order steeds handmatig te kopiëren. Vele voordelen worden toegeschreven aan ordercommunicatie systemen. Onduidelijkheden als gevolg van moeilijk leesbare of onvolledig ingevulde receptenbriefjes worden vermeden. Het verminderen van het aantal onnodige telefoontjes bespaart kostbare tijd van artsen. Medicatiekosten kunnen verminderd worden wanneer het voorschrijven gebaseerd is op het formularium van het ziekenhuis. Elektronische signaleringen waarschuwen de arts over doseringen, interacties van geneesmiddelen, geneesmiddelallergieën en tenslotte de mogelijke schadelijke gevolgen van het toedienen van geneesmiddelen ('adverse drug events'). Ordercommunicatie systemen worden dan ook gezien als een technologie waarmee het aantal medische fouten verminderd en de patiëntveiligheid bevorderd kan worden. Het gezaghebbende Institute of Medicine van de National Academy of Sciences in de Verenigde Staten publiceerde in 2000 en 2001 twee rapporten waarin werd aangedrongen op de implementatie van dergelijke systemen [3, 4].

Vier jaar later echter constateerde Joan Ash en haar collega's dat nog slechts in minder dan 10% van de Amerikaanse ziekenhuizen ordercommunicatie systemen waren geïmplementeerd [5]. De grote kloof tussen de vermeende voordelen en de feitelijke situatie bewijst hoe moeilijk het is om zulke systemen in de klinische praktijk te laten functioneren.

Een onderzoek naar de implementatie van informatiesystemen kan niet los gezien worden van een begrip van de organisatorische context. De sociotechnische benadering die ik in dit onderzoek hanteer, benadrukt het belang van de verwevenheid van technologie en sociale omgeving. Zij is niet zozeer een welomschreven theorie, maar een perspectief dat tot ontwikkeling is gekomen in het onderzoeksgebied van informatiesystemen in organisaties en 'computer supported cooperative work', en in wetenschaps- en techniekstudies. Het sociotechnische perspectief stelt de onderzoeker in staat diverse aspecten van de verwevenheid tussen organisatie en technologie te verkennen en te doorgronden. De sociotechnische benadering in deze studie heeft drie algemene kenmerken.

Op de eerste plaats gaat de benadering ervan uit dat de rollen en taken van zorgprofessionals nauw met elkaar en de organisatorische omgeving verbonden zijn. Materiële artefacten, zoals een formulier, de inrichting van een kantoor of een computersysteem, structureren van zorgprofessionals, verdeelt hun verantwoordelijkheden en bepaalt hoe hun relaties eruit zien. Bijvoorbeeld, een intakeformulier voor patiënten stuurt hoe verpleegkundige van een patiënt een anamnese zal afnemen en welke informatie zij opschrijft. Als het formulier vervangen wordt door een computersysteem verandert de manier waarop de verpleegkundige anamnese afneemt. Op het papieren formulier slaat de verpleegkundige de vragen over die zij niet relevant vindt voor de anamnese. Een computersysteem dwingt haar alle vragen te beantwoorden, ook al zijn ze niet relevant voor de patiënt die ze nu ziet.

Ten tweede is medisch werk typisch een proces van samenwerking en gedeelde verantwoordelijkheid. In een klassieke studie beschrijven Anselm Strauss en zijn medeonderzoekers hoe patiëntenzorg gekarakteriseerd kan worden als het 'managen van een zorgtraject [6].' Dit houdt in dat alle betrokkenen, inclusief de patiënt, hun activiteiten coördineren en op elkaar afstemmen om zorg mogelijk te maken. Medisch werk is heel pragmatisch en fluïde omdat zorgprofessionals steeds reageren op onverwachte gebeurtenissen en omstandigheden die zo kenmerkend zijn in de gezondheidszorg.

Tenslotte is een grondig empirisch inzicht in medische werkpraktijken noodzakelijk om te begrijpen hoe een informatiesysteem deze praktijken kan ondersteunen. Kwalitatieve onderzoeksmethoden zijn uitermate geschikt om inzicht te krijgen in de complexe relaties tussen zorgprofessionals en een informatiesysteem. De methoden omvatten onder meer observatiestudies, interviews en documentstudies. Observatiestudies geven inzicht hoe zorgprofessionals hun taken uitvoeren, zoals het gebruik van een computer, hoe zij medische orders invoeren en hoe zij met collega's samenwerken wanneer zij gebruik maken van een informatiesysteem. Interviews geven inzicht in de manier waarop zorgprofessionals feiten en gebeurtenissen waarnemen en beoordelen en zijn vooral waardevol wanneer er geen andere manier bestaat om gegevens te verzamelen, zoals over gebeurtenissen in het verleden. Documenten vormen een rijke bron van gegevens over de organisatie en in deze studie omvatten zij beslis- en implementatiedocumenten, vergaderverslagen, gebruikershandleidingen, informatiebulletins, artikelen en wetenschappelijke publicaties. De combinatie van verschillende gegevensbronnen stelt de onderzoeker in staat om feiten en gebeurtenissen te correleren en valideren.

Het doel van de studie beschreven in dit proefschrift is om de implementatie van geautomatiseerde ordercommunicatie systemen te begrijpen vanuit een sociotechnisch perspectief.

De studie bestaat uit drie delen. In het eerste deel (hoofdstuk 1) wordt een implementatiemodel van informatiesystemen in organisaties zoals ziekenhuizen beschreven. Dit model vormt als het ware het decor van de casestudies in dit proefschrift. Het tweede deel (hoofdstuk 2 en 3) beschrijft casestudies van de implementatie van ordercommunicatie systemen in het Universitair Medisch Centrum St Radboud te Nijmegen en het Atrium Medisch Centrum te Heerlen. In het laatste deel (hoofdstuk 4, 5 en 6) worden de casestudies in een breder perspectief geplaatst door een vergelijking met casestudies van de implementatie van ordercommunicatiesystemen in Amerikaanse ziekenhuizen. Bovendien werden interviews gehouden met Amerikaanse deskundigen op het ordercommunicatie systemen over professionele samenwerking, de workflow van medische orders en de impact op de kwaliteit van zorg. Het laatste deel van de studie werd uitgevoerd tijdens mijn verblijf in de afdeling medische informatica en klinische epidemiologie van de Oregon Health & Science University in de Verenigde Staten.

De volgende *onderzoeksvragen* komen in het proefschrift aan de orde.

- Wat zijn de algemene kenmerken van een implementatietraject van een zorginformatiesysteem?

- Hoe kunnen de uitkomsten van de implementatie van een ordercommunicatie systeem in een ziekenhuis worden verklaard vanuit een sociotechnisch perspectief?

- Welke factoren kunnen vanuit het perspectief van medisch werk gezien, de verschillende uitkomsten verklaren van de implementatie van een ordercommunicatie systeem in twee Nederlandse ziekenhuizen?

- Hoe kunnen de implementatiestrategieën van ordercommunicatie systemen in Nederlandse en Amerikaanse ziekenhuizen vergeleken worden en op welke wijze worden artsen erbij betrokken?

- Hoe kan de perceptie van experts op het gebied van ordercommunicatie systemen op de stroomlijning van medische werkprocessen, professionele samenwerking en de impact ervan op de kwaliteit van zorg bijdragen tot een beter begrip van ordercommunicatiesystemen?

De hoofdaanname in hoofdstuk 1 van dit proefschrift is dat een implementatieproces gekenmerkt kan wordt door fases en dat het proces in voortdurende wisselwerking verkeert met de organisatorische omgeving. De fases zijn niet scherp omschreven in de zin dat ze een gedefinieerde input en output kennen, maar laten toe de geëigende activiteiten vast te stellen om een systeem te implementeren. De implementatie staat in wisselwerking met medisch werk dat de kernactiviteit van een ziekenhuis is. De interactie heeft een etnografische notie in de zin dat een goed begrip van medisch werk nodig is om te begrijpen hoe een informatiesysteem daarin past. Een implementatieteam moet daarom kunnen doorvragen, observeren, doorgronden en gevoelig zijn voor signalen en gebeurtenissen op een wijze die Marc Berg als essentieel beschouwt voor de sociotechnische benadering [7].

In hoofdstuk 2 behandel ik de vraag hoe vanuit een sociotechnisch perspectief de implementatie van een ordercommunicatie systeem geïnterpreteerd kan worden. In het hoofdstuk wordt een gedetailleerd verslag gepresenteerd van de implementatie van een ordercommunicatiesysteem in het UMC St Radboud vanaf het moment dat de behoefte aan zo'n systeem werd gesignaleerd tot het moment dat twaalf jaar later de implementatie van de kernfunctionaliteit van ordercommunicatie werd gestaakt. De casestudie maakt het conflict zichtbaar tussen de rationaliteit van het systeem uitgedrukt in technische en functionele specificaties en het feitelijke gebruik. In het nieuwe systeem waren het gebruik van een toetsenbord en het onthouden van functietoetsen niet meer nodig en het implementatieteam dacht dat het systeem daardoor gemakkelijker te gebruiken zou zijn en men met minder menskracht toe zou kunnen. Het tegendeel bleek waar: het systeem werkte zeer vertragend en meer medewerkers moesten aangenomen om de werklast te verlichten. De gebeurtenis stemde niet overeen met de verwachtingen dat op administratief personeel bezuinigd kon worden. Ik introduceer het Engelstalige begrip 'fit' als een overeenstemming tussen de eisen die voortvloeien uit werkpraktijken en de mogelijkheden van het informatiesysteem. Ik stel dat 'fit' geen intrinsieke eigenschap is van een technologie of een werkpraktijk, maar dat het gemaakt moet worden. 'Fit' is het resultaat van een proces waarin zowel werkpraktijken en technologie veranderen. Gebruikers zullen 'knoeien' met het systeem om sommige taken gemakkelijker of efficiënter te maken. Het ordercommunicatie systeem was ontworpen voor de Amerikaanse situatie waarin patiënten op klinische afdelingen waren opgenomen en het moest aangepast worden aan het Nederlandse systeem van patiëntenzorg in poliklinieken. Vervolgens maakte de casus zichtbaar dat de tijdsduur van de implementatie cruciaal was. Beslissingen over de keuze van de technologie waren aan het begin van het implementatietraject uitermate zinvol en pas achteraf bleek dat ze de gebruikers beperkingen oplegden. In de tussenliggende tijd raakten de gebruikers vertrouwd met Windows-toepassingen en verwachtten zij dat het ordercommunicatie systeem zich op dezelfde manier zou gedragen. Het schermontwerp zag er ouderwets uit. Het proces was heel vergelijkbaar met de verdringing van het tekstverwerkerprogramma WordPerfect door Microsoft Word. Het punt is dat deze verandering niet kon worden voorspeld. De verandering gebeurde niet plotseling; het werd gaandeweg duidelijk naarmate een nieuwe technologie de markt penetreerde. In navolging van Wanda Orlikowski's terminologie noem ik dit verschijnsel 'emergent change [8].' De uitdaging ligt niet in het voorspellen van verandering, maar op het formuleren van een antwoord daarop. Tenslotte laat de casus zien hoe nauw technologie en organisatie zijn vervlochten. Gebruikers denken vaak dat de introductie van een nieuw systeem ook gepaard gaat met nieuwe computertechnologie. In werkelijkheid dicteerde de reeds aanwezige computertechnologie en technische infrastructuur de keuze voor een nieuw informatiesysteem. Complexe hardware vereist expertise voor ontwikkeling en onderhoud, en expertise is niet zo gemakkelijk te vervangen.

In hoofdstuk 3 probeer ik de verschillende uitkomsten van de implementatie van ordercommunicatie systemen in het UMC St Radboud en het Atrium Medisch Centrum te verklaren. In tegenstelling tot het UMC slaagde Atrium erin om de volledige functionaliteit van ordercommunicatie te implementeren, maar in beide ziekenhuizen namen artsen niet aan het proces deel. Ik verklaar de verschillen door de aard van medisch werk als uitgangspunt te nemen. Ik stel dat gebruikers meer willen weten hoe hun werk verandert als gevolg van het systeem, dan dat ze geïnteresseerd in de specifieke eigenschappen ervan. Het is de bereidheid om veranderingen in werkpraktijken te aanvaarden die cruciaal is voor de acceptatie van een informatiesysteem. Ik stel dat de relatie tussen medisch werk en de professie niet zo sterk is als het lijkt. Artsen beschouwden het elektronisch invoeren van orders als niet behorend tot hun professionele domein, verpleegkundigen en secretaresses zagen het echter als iets dat zij al lang deden; zij maakte daarom het elektronisch invoeren van orders tot onderdeel van hun dagelijkse werkpraktijken.

In hoofdstuk 4 en 5 beschrijf ik de vergelijking van de implementatiestrategie van ordercommunicatie systemen in drie Nederlandse en drie Amerikaanse ziekenhuizen. Uit de vergelijking blijkt dat de verschillen tussen Nederland en de Verenigde Staten niet wezenlijk zijn. Alle ziekenhuizen noemden kostenbesparingen en vergroting van efficiency als de belangrijkste redenen om ordercommunicatie systemen in te voeren. Zelfs in projectmanagement, waarbij de Amerikaanse nadruk op leiderschap geplaatst kon worden tegenover de Nederlandse consensus en compromis cultuur, bleken de verschillen meer gradueel dan absoluut. Uit de bestudeerde casussen bleek voorts dat alle implementaties minimaal vijf jaar duurden. Klaarblijkelijk is deze tijdsduur wezenlijk voor elke implementatie van een complex informatiesysteem. Ziekenhuisbestuurders zouden daarom niet moeten rekenen op het snel terugverdienen van investeringen in informatietechnologie, maar eerder plannen voor langdurige trajecten en de daaraan gerelateerde onzekerheid incalculeren. De implementaties waren voornamelijk geïnitieerd door het management en leken niet tegemoet te komen aan de behoeften van de artsen. Op het moment echter dat artsen het systeem begonnen te gebruiken, probeerden zij het systeem meer toe te snijden op de inrichting van hun werkpraktijken. In plaats van iedere order apart in te voeren, maakten zij combinatieorders voor specifieke groepen van patiënten die zij vaak zagen. Het elektronisch invoeren van combinatieorders vonden zij veel efficiënter dan het handmatig schrijven van orders. Ik vermoed dat hun klinische expertise de artsen in staat stelden om het gebruik van ordercommunicatie systemen op een hoger plan te brengen en zo tot deel van hun werkpraktijken te maken. Deze manier van ‘geïmproviseerde’ verbetering is wat Claudio Ciborra ‘bricolage’ noemt [9]. De verbetering is niet echt gepland, het is wezenlijk voor professionals om een informatiesysteem in hun werkpraktijken in te passen, en het kan daarom als een innovatie betiteld worden. In Atrium Medisch Centrum maakten verpleegkundigen en secretaresses het ordercommunicatie systeem zich eigen, maar hun gebrek aan klinische expertise weerhield de ontwikkeling van combinatieorders.

In hoofdstuk 6 tenslotte verbreed ik het begrip van ordercommunicatie door vraagstukken van professionele samenwerking en workflow erbij te betrekken en na te gaan hoe ordercommunicatie de kwaliteit van zorg beïnvloedt. Ik stel hier dat ordercommunicatie gekenmerkt wordt door een hoge mate van samenwerking tussen artsen, verpleegkundigen en andere zorgverleners. Een ogenschijnlijk eenvoudig proces zoals het voorschrijven van een geneesmiddel aan een patiënt is het resultaat van artsen en verpleegkundigen die met elkaar overleggen en gezichtspunten uitwisselen totdat een beslissing is overeengekomen. De beslissing wordt als een medicatieorder ingevoerd. Ordercommunicatie systemen zijn echter gebaseerd op een nogal simplistisch en lineair workflow model van medische orders en ontworpen voor individueel gebruik door artsen, en daarom is een conflict tussen dergelijke systemen en het feitelijk gebruik niet denkbeeldig. In werkelijkheid maken apothekers, verpleegkundigen en de patiënt deel uit van de workflow. De geïnterviewde deskundigen erkennen hoe moeilijk het is om ordercommunicatie systemen deel te laten uitmaken van een klinische werkomgeving. Een juist begrip van ordercommunicatie systemen als een gezamenlijke inspanning van zorgprofessionals vraagt inzicht hoe orders tot stand komen en hoe ze verwerkt worden, hoe de workflow er uit ziet en hoe risico's voor de patiëntenzorg geïdentificeerd en verkleind kunnen worden, vooral wanneer de order vele handen passeert.

De algemene conclusie van het proefschrift is dat het invoeren van een informatiesysteem zowel de werkpraktijken als de technologie verandert. De verandering is in essentie een sociaal proces. Veranderingen zijn niet gemakkelijk te voorspellen. Dat is een dilemma voor een implementatieteam. Wellicht wil het team een systeem ontwerpen met behulp van blauwdrukken en het hierna systematisch implementeren. Claudio Ciborra adviseert echter het team om improvisatie een wezenlijk deel te laten zijn van het implementatieproces, om toekomstige gebruikers te laten 'knoeien' met het systeem en uit te laten vinden hoe het het beste ingepast kan worden in de dagelijkse werkpraktijk, om te plannen voor het onverwachte en nieuwe gebruikspraktijken positief tegemoet te treden en strikte sturing te laten varen. De generalisatie van de bevindingen is gelegen in het principe, niet in de voorspelbaarheid van individuele implementatietrajecten.

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Writing a thesis is work of solitude; working for a thesis is not possible without the help of people. Basically there are three categories of people: people who helped me in my path towards my thesis, people who helped me during the thesis work and people who formed part of my social network.

My latent interest of being at the forefront of innovation was nurtured when I as a student of physics did my masters dissertation work in the Department of Experimental Solid State Physics (EVSF 2) of Radboud University Nijmegen. The then head of the department, professor Peter Wyder, considered students like me as an integral part of his research team and encouraged them to give talks at the weekly research meetings. After graduation, I got a teaching position in higher professional health care education, but I was not a mere teacher of physics courses to nursing students. Numerous people encouraged me to explore the opportunities of computers in health care and translate that knowledge into courses. This got me involved in national projects to develop curriculum frameworks for health informatics. It is impossible to thank all these people individually, but I make an exception for Sylvia Hoekstra, who partnered with me during my career for almost twenty years. A crucial step in the development of my interest in health informatics and research was my period as a guest researcher at the Institute of Medical Informatics of Erasmus MC from 1988 to 1992. Though my efforts to write a thesis then did not materialize, it did lay the groundwork for the research described in this thesis. I thank therefore professors Jan van Bemmel and Johan van der Lei, Astrid van Ginneken and other colleagues of the institute that they gave me the opportunity to get acquainted with research in medical informatics.

In January 1993 I took a position as senior lecturer at Fontys Hogescholen in Eindhoven with the special task to develop a model curriculum of health informatics for Dutch higher professional health care education and to coordinate efforts to develop learning materials. The projects allowed me to address the question how information systems might fit in clinical practice, which eventually led to Fontys Hogescholen funding the initial phase of the research described in this thesis. I therefore thank Peter Roosenboom and Harmen Grebel for giving me the opportunity to explore these insights and my Causa colleagues Anke Duijnhouwer, Bas de Leng, Herman van Lieshout, Anne Oostendorp, Marianne Schade, Jan Steyaert and others for our valuable and pleasant collaboration.

International networking was extremely important for the development of my knowledge and insights and I met many people who contributed to that.

Among others I mention Cynthia Bournazos and Bonnie Kaplan. Two occasions determined the path of my career. In 1996 the president of the European Federation for Medical Informatics, late professor Jean-Raoul Scherrer, supported the founding of Working Group "Organizational Impact of Medical Informatics," which enabled me to bring together people interested in this emerging field and contribute to European medical informatics conferences. The second occasion was the development and start of a master course of health informatics that specifically addressed the organizational issues of health informatics. I thank Victor Peel and Graham Wright for our collaboration in this project, which also resulted in a couple of joint publications. It is fortunate that the master course found a new home at Erasmus University Rotterdam.

The research described in this thesis took off in 1997 when Dick Herfst, director of nursing at UMC St Radboud in Nijmegen, suggested that I investigate the implementation of their new hospital information system. I acknowledge the board of directors of UMC St Radboud for allowing this research and the project leaders Andries Hoitsma and Herman van Beem for their support. In the person of Wim Beckers I acknowledge the help of all implementation team members during the fieldwork.

Doing research without an academic ground base is impossible. At a conference in Philadelphia in June 1977 Joan Greenbaum suggested that professor Hans Doorewaard of the Faculty of Management Sciences of Radboud University Nijmegen would be a good supervisor. Sometimes you have to travel far abroad to get to know someone next-door. Hans allowed me to take part in the weekly research seminars in his group and to let me discuss my earliest ideas of the research. I am grateful that he is now my second promotor.

My academic ground base became more solid when in 1999 I was appointed as assistant professor at the Institute of Health Policy and Management of Erasmus University Rotterdam. Marc Berg was key in that move. In 1996 through a mutual acquaintance I met Marc when he was still at Maastricht University and I found in him a person who immediately understood about my interests in the complex relationship between information technology and health care work. When Marc came to Rotterdam he asked me to join him and to develop courses about IT and health care. He was instrumental to get me on the track of theorizing, but immediately recognized that because of my background I would never become a theorist and that I would foremost remain an empiricist. He knew how to handle my long-windedness and my unorganized way of managing affairs. I am very grateful that he is my promotor.

Next to my research in UMC St Radboud I was able to conduct fieldwork in Atrium Medical Center in Heerlen in 2001 and 2002. I thank the board of directors of the hospital for this opportunity and Roger Renkens and his colleagues for all practical help.

Very important was the opportunity to conduct research as a visiting scientist at the Department of Medical Informatics and Clinical Epidemiology of Oregon Health & Science University in Portland, Oregon, in 2003 and 2004. I am grateful to Joan Ash that she invited me to the Menucha expert meetings to discuss the difficulties and challenges of implementing CPOE systems and to be member of her research team POET, the Physician Order Entry Team. I am much obliged to Joan that she is my copromotor. I thank Jim Carpenter, Cody Curtis, Richard Dykstra, Ken Guappone, Veena Seshadri, and Dean Sittig as members of POET for being inspiring colleagues. I thank William Hersh especially, not only for hosting me at his department, but also for facilitating the second international conference Information Technology in Health Care, Sociotechnical Approaches in Medical Informatics, in September 2004 in Portland. This successful conference was a hotbed for new research ideas. I am grateful to my co-chair Paul Gorman for the intensive and successful collaboration in this event.

My intellectual home base is our research group RITHM (Research in IT in Health care and Management). The weekly meetings are important to discuss the ripe and unripe ideas of research. I thank Roland Bal, Barbara Blank, Antoinette de Bont, Stans van Egmond, Bert Huijsman, Yvonne Jansen, Femke Mastboom, Habib Pirnejad, Irma van der Ploeg, Jolande Verhulst, Brit Ross Winthereik and Teun Zuiderent for being good colleagues, and especially Samantha Adams and Arjen Stoop for our intensive discussions about almost any imaginable subject.

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Nijmegen, July 2005

# CURRICULUM VITAE

Jos Aarts was born in Heerlen on November 4, 1951.

In 1970 he graduated from 'gymnasium' at Jansenius Scholengemeenschap (now Reynaertcollege) in Hulst. He studied physics at Radboud University Nijmegen, obtained in 1978 a BSc in physics and mathematics and in 1980 an MSc in physics education with the dissertation "Fabry-Pérot Interferometry at Low Temperatures." From 1980 until 1999 he held several posts in higher health care education where he designed and taught advanced health informatics courses. His last position was at Fontys Hogescholen in Eindhoven where he developed a model curriculum of health informatics and coordinated a project to develop learning materials for this curriculum.

Since 1999 he is employed at the Institute of Health Policy and Management of Erasmus MC in Rotterdam, initially as an assistant professor and currently as a senior research scientist. He is chair of Working Group 'Organizational Impact of Medical Informatics' of the European Federation for Medical Informatics. He is a member of IFIP Working Group 8.2 'Information Systems and the Organization.'

He is married to Ricky van Oorschot. They have one daughter, Anne, who is a student of law at Utrecht University.

# NOTES