Adoption of an electronic health record: untangling a deadlock situation in four Dutch academic hospitals

Ernst F. Albers

Supervisors:

Dr. Ir. T.A.M. Spil
Prof. Dr. R.A. Stegwee
Ing. D.R. Utermark RE

Abstract: This paper presents a model for predicting the likelihood of success of an EHR, based on the dimensions relevance, participation, system quality and external environment. The study of four Dutch academic hospitals and two Dutch EHR suppliers shows that specialties in the hospitals are optimizing their own systems without considering the goals of the hospital in total. Implementing an EHR is limited by a threshold. Before an EHR can achieve its expected improvements in healthcare this threshold needs to be passed. Savings of time and availability of data are found to gain relevance the most. Management involvement is necessary to optimize and standardize workflows. The EHR has to adapt to these optimized workflows. Participation of end-users is higher when using self-made EHR's compared to EHR's of external suppliers. Further research is necessary to investigate the service quality of self-made EHR's. Agreement among healthcare professionals about the data set which need to be shared and standard medical vocabulary, are necessary, before a national wide EHR will succeed

Keywords: adoption hospital; electronic health record; external environment; participation; relevance.

1 Introduction and research problem

The public and political pressure for a more efficient healthcare provision is rising, due to a number of external factors. An ageing population and increasing number of patients with chronic illnesses are causing a growing demand and thereby growing healthcare expenditures (Mongan et al., 2008). Increased living standards and the development of consumerism in healthcare are putting additional pressure on the healthcare system (Ozmon, 2007). Essential elements of 21st century healthcare emphasizing the potential gains of an Electronic Health Record (EHR) are: widespread use of evidence-based medicine (including adaptive evidence-based decision support systems), robust information infrastructure, aligned reimbursement incentives, regulatory requirements and a workforce skilled in evidence-based medicine (Kawamoto et al, 2005; Frist, 2005).

The expression EHR is one out of many for computer-based systems in healthcare. The definition of an EHR used in this research is based on the definition of a computer-based patient record of the Institute of Medicine (Dick et al., 1997):

> "An EHR is a patient record that resides in a computer system specifically designed to support care providers by providing accessibility to complete and accurate patient data, medical alerts, reminders, clinical decision support systems, links to medical knowledge and other aids." (Dick et al., 1997)

This definition is made primarily from the viewpoint of care providers. In order to stress the importance of patient centeredness, we would like to add a sentence to the definition based on the EHR definition of Iakovidis (1998):

> "The purpose of an EHR is supporting the continuity of care for an individual's lifetime and ensures confidentiality at all times." (Iakovidis, 1998)

Pretensions about the benefits of an EHR, untangling all problems in healthcare, consist for nearly twenty years. The frequently delayed promise of a national interoperable EHR strengthens these pretensions. The current Dutch government promised a national interoperable EHR in September 2009 (Coalition agreement, 2007). This declaration has been around for over a decade already, proved by the necessity of the 13th annual national EHR congress.

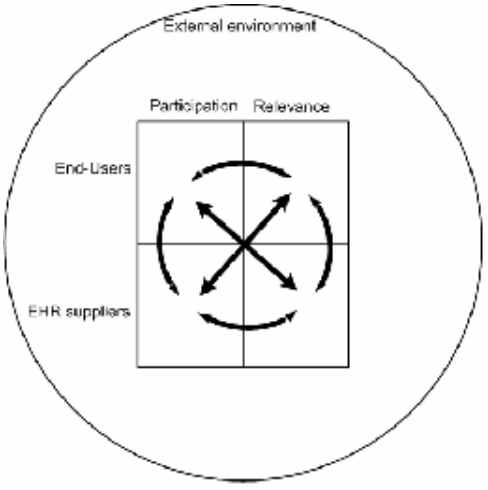
More than thirty years ago, software was introduced in hospitals. Initially the software was only supporting the back-office processes. Later on the software started supporting the front office of the healthcare process more and more. This shift can be seen as the development towards an EHR (Staggers et al., 2001). The large-scale introduction of networking in the 1990's created a need for data interchange protocols and created a controversy between networked ''best of breed'' applications with strong functionality and single technology integrated systems. Nowadays the software legacy systems supporting all different facets of the healthcare processes can still be found in many hospitals, since many hospitals have chosen to adopt a "best of breed" strategy (Berner et al., 2005). The "best of breed" strategy as chosen by most hospitals does encompass great problems with interoperability of the operational EHR (Greenberg and Welcker, 1998).

The implementation of an EHR has proven to be a path ridden with risks and dangers (Berg, 2001). EHR implementations often lead to additional burdens on already overloaded staff, instead of complementing and improving clinical care (Walsh, 2004). The problem of adoption by physicians of the EHR is described by Schuring and Spil as a gap between expected and perceived performance and effort. The problem is unraveled by a content and a process perspective (Schuring and Spil, 2003).

The EHR adoption decision is influenced by the external environment, consisting of different actors: The Ministry of Health with their National ICT Institute for Healthcare (NICTIZ, Nationaal ICT Instituut in de Zorg). NICTIZ is putting pressure on hospitals to connect to the national ICT infrastructure. Regional EHR initiatives, mostly collaborations of pharmacies, general practitioners, home care organizations and hospitals. Collaborations between academic hospitals in most cases focused on medical research. The last identified external factor is a pressure for registration of medical treatments by the Dutch hospital accreditation institute (NIAZ, Nederlands Instituut voor Accreditatie van Ziekenhuizen). NIAZ is certifying hospitals for delivering a high quality of reproducible care, for which adequate registration is needed.

The quality of an EHR influences both participation of end-users and relevance for end-users, while participation and relevance influences the success of an EHR. In this paper we argue that the Dutch situation is in a deadlock situation. End user participation from the start is needed to leverage the relevance. However, relevance is needed to induce participation (Katsma et al., 2007). In figure 1 the Dutch situation is presented: the adoption decision is influenced by the external environment, the quality of the system, participation and relevance. The factors are influencing each other and take the shape of a vicious circle. Improvement from one or more factors is needed to break out of the deadlock situation of no participation, no relevance. To unravel the deadlock situation we will derive a framework and apply the framework to four academic hospitals in the Netherlands.

Figure 1 Dutch EHR deadlock situation adapted from Gallivan (2001).



The contribution of this research is threefold. Firstly this research contributes to the existing research in the Information Systems field by gathering information from Dutch academic hospitals, while so far research has been done mostly on non-academic hospitals in the Netherlands. In the second place this research contributes by investigating both the end-user and EHR supplier side. In the third place this research aims to give concrete answers to questions concerning how to break through the vicious circle of relevance and participation. Thereby does this research aim to increase relevance and participation for both the end-users and the EHR suppliers.

The main research question, which this research aims to answer, is: How to untangle the deadlock situation of relevance and participation? This question concerns the following topics:

Q1 What is the deadlock situation?

Q2 How can end-user participation for the use of an EHR be stimulated?

Q3 How can relevance of an EHR be improved?

The rest of this article is structured as follows: in Section 2 we will elaborate on participation, relevance and the supplier side as represented in figure 1 and derive a framework from literature on how to untangle the deadlock situation. Section 4 explains how this framework is applied in four Dutch academic hospitals. In section 4 the results of the cases are analyzed individually. Section 5 presents an analysis and discussion and in Section 6 we return to our main research question and discuss the overall results.

2 Theoretical background

2.1 Relevance

Benefits of an EHR are reported in literature in the form of theoretical positive financial returns on investments to health care organizations, due to savings caused by reductions in medical errors and inefficiency (Wang et al., 2003). The EHR is helping clinicians in making better decisions (Tang et al., 2006), making healthcare safer for the patient and more satisfying for the clinician (Ash, 2005). The EHR has the potential for annual savings for the overall healthcare system, by improving healthcare quality and efficiency (Hillestad et al, 2005). Although, evidence

supporting mainly hypothetical benefits of the EHR for physicians, clinic practices and health care organizations is limited (Tang et al., 2006).

Thus far the focus of relevance of EHR's is on the availability of information at any time and any place, which does not meet the end-users' expectations (Katsma et al., 2007). Promises for better quality of care should prompt a call for the adoption of an EHR (Ford et al., 2005).

The perspectives of relevance and participation from Spil et al. (2004) are based on innovation diffusion theories. Relevance is derived from Rogers' (1995) relative advantage, Davis's (1989) perceived usefulness, Thompson's (1967) job-fit and usefulness and outcome expectations (Compeau, 1995). Spil et al. (2004) distinguish between Macro-relevance and Micro-relevance. Macro-relevance defined as: "the degree to which the user expects that the IT system will solve problems or help to realize his actual goals". Micro-relevance defined as: "the degree to which IT-use helps to solve the here-and-now problem of the user in his working process".

In classical innovation theory, innovation is seen as a linear process, either as technology push, need-pull or a combination of both. The healthcare environment is characterized by multiple organization structures, a long history of power struggles between professional groupings and is shaped by an intense political macro environment (Wainwright, 2007). Yarbrough argues that classical models fall short in explaining the influence of external variables and barriers to technology acceptance (Yarbrough, 2007). The innovation diffusion theory is based on voluntary adoption. A limitation of this theory is its disability to distinct between organizational and individual implementation outcomes after authoritarian or contingent adoption decisions are made (Gallivan, 2001).

Looking at the Dutch situation we see that the primary authority adoption decision of Second grade EHR's (Handler, 2007) took place in (almost) all hospitals. Since 2005 hospitals started with implementing Third grade EHR's, but most hospitals are not up to it yet (Freriks, 2007). We will therefore focus further on the individual adoption process.

Gallivan describes three factors that mediate between primary and secondary (individual) adoption: managerial interventions, subjective norms and facilitating conditions. Managerial interventions describe the actions taken and resources made available by managers to expedite secondary adoption. We will elaborate further on managerial interventions in the participation section. Subjective norms are best described by Micro-Relevance and Macro-relevance. Schuring and Spil (2003) found micro-relevance as a key factor in explaining IT-use in their case studies. The third construct, facilitating conditions is described by Gallivan as factors that can make implementation more- or less-likely to occur (Gallivan, 2001). Katsma et al. (2007) describe this factor more extensively as participation, which should increase micro-relevance perception of the involved user.

Even if an EHR is able to solve the here-and-now problem of the end-user in his work process, it might still not come to actual use of the system, even years later. Fichman and Kemerer (1999) call this an assimilation gap, which is common for technologies with a high implementation complexity. In the Dutch situation any time that a doctor devotes to EHR use does not lead to increased income potential and for hospitals it is not clear if they will benefit (Clemons and Row, 1993). We assume financial and time saving incentives to have positive effects on EHR use, as it is widely recognized in literature (Yarbrough, 2007; Benson, 2002; Doolan and Bates, 2002; Blumenthal, 2006, Ash and Bates, 2005). The identified relevance dimensions from Table 1 are used to analyze their effect on EHR adoption.

Table 1: Relevance dimensions

Dimension	Items identified in this research:
Expectations	outcome expectations, or Macro-relevance (Spil et al., 2004)
Incentives	time saving incentives, financial incentives (Yarbrough, 2007; Benson, 2002; Doolan and Bates, 2002; Blumenthal, 2006, Ash and Bates, 2005)
Subjective norm	micro-relevance (Spil et al., 2004)

2.2 Participation

From the process perspective it is argued that extensive participation by different care professionals during the implementation is significantly contributing to the acceptance of an EHR (Hartwick and Barki, 1994). Although end-user participation is of paramount importance to foster ownership of the system by future users (Berg, 2001), still many organizations fail with taking organizational aspects into account during their implementation process (Boer and During, 2001).

Willingness to change is an important factor in adopting new technologies. This factor is called "Spirit" by Poole and DeSanctis (1990) and is defined as the general intent of something. The spirit of technology provides legitimacy to the technology (Giddens, 1979). In this research "Spirit" is best compared with the definition of Macro-relevance. The process of appreciation of the technology is influenced by several factors:

- the degree to which end-users believe that other end-users will use the system (Vician et al. , 1992)
- "critical mass", the value of the technology increases when the technology diffuses through the organization; the so called laggards are influenced by early adopters (Markus 1990)
- agreement among end-users on how to use the system (Kirsch and Jackson, 1991)

Top management support and project management are found to be critical factors for successful implementation of information systems (Fui-Hoon Nah et al, 2001; Gallivan, 2001). Berg (2001) argues for presence of upper management from a practical point of view: without the presence of upper management the processes tends to loose direction and thus agreement among end-users. The extent to which people are willing to change depends very much on the management of change (Wissema, 2000). The management is able to demote and create barriers when end-users are disempowered (Kotter and Cohen, 2002).

The model of Gallivan (2001) assumes a direct influence of managerial interventions on end-user adoption. Based on our proposed model as presented in figure 1 we assume a more indirect relation. In our assumption managerial interventions are influencing the level of participation of end-users, although the influence of managerial intervention is not equally perceived by al subordinates and is dependent on context specific characteristics of individuals (Leonard-Barton and Deschamps, 1988). We identified concrete managerial actions to be taken, in order to increase end-user participation. The managerial actions build upon the work of Agarwal (2000), Scott and Bruce (1994), Sein et al. (1998), Hartwick and Barki (1994), Kotter and Cohen, 2002. The result is shown in Table 2, which includes the items that have been used for this research in Dutch academic hospitals.

Table 2: Management dimensions to increase participation (based on: DeSanctis and Poole, 1994)

Dimension	Items identified in this research:
Decision Process	structured in a way, so that users are actively engaged in the process (Hartwick and Barki, 1994)
Leadership	management focused on early adopters, to create "critical mass" and can bolster other end-user's self confidence (Markus, 1990; Kotter and Cohen, 2002)
Conflict management	end-user interactions are orderly and lead to one direction (Berg, 2001)
Atmosphere	creation of work culture, that is conductive to learning and experimentation and reward system that inspire, promote optimism and build self-confidence (Scott and Bruce, 1994; Agarwal, 2000; Sein et al., 1998; Kotter and Cohen, 2002)

2.3 EHR suppliers

The evolutionary process of the development of the EHR has changed software packages from translating existing paper based data into passive systems, towards active systems 'fed' with the input of the caregivers. The most recent EHR's are more advanced and are supporting clinical episodes and encountering clinicians. They are known as Third Grade EHR's, or 'The Helper' (Handler, 2007).

To be able to propose incentives and mandates for EHR suppliers we first analyze the interplay between end-users and EHR suppliers via the EHR system. Success of the interplay can be divided into three categories according to the revisited approach of Delone and McLean (2002): (1) information quality, (2) system quality and (3) service quality. In their model the three categories influence both the intention to use, as well as the user satisfaction. In our study the intention to use is best compared with macro-relevance, whereas user satisfaction is best compared with micro-relevance. Van der Meijden et al (2003) conducted a literature study on patient care information systems and identified attributes per dimension. The attributes are supplemented with literature findings, as can be found in Table 3:

Table 3: Success dimensions and their attributes (based on Delone and McLean, 2002 ;Van der Meijden et al, 2003; Franke and von Hippel, 2003; Lovis et al, 2003; Sutherland and van den Heuvel, 2006)

Dimension	Attributes
Information Quality	completeness, data accuracy, legibility
System Quality	ease of use, time savings, security, workflow support, interoperability, customization possibilities, expression power
Service Quality	availability, support

In order to be able to understand how EHR suppliers can increase macro-relevance for the end-users, we need to better understand the Dutch EHR market. The Dutch market consists of one hundred hospitals and about twenty EHR

suppliers. The Dutch 'DBC' standard for registration and declaration deviates from the international DRG standard for registration and declaration, which makes it necessary for international EHR suppliers to moderate their systems. The interoperability of EHR's in the Netherlands, which could lead to reductions in medical errors (Wang et al., 2003; Institute of Medicine, 1999) and sharing of health record information seamlessly and meaningfully (Kalra and Blobel, 2007) is given much attention and has led to efforts on regional and national level.

On a national level NICTIZ has created architecture specifications and interoperability standards for a national health information infrastructure, known as AORTA. The EHR's have to comply with the specifications and standards in order to connect to the infrastructure. The Dutch government made legislation, which makes it possible to identify patients in an EHR based on their social security number. Actions on a regional level are mainly focusing on connecting information systems of pharmacies, general practitioners and hospitals. It is worthwhile mentioning that the general practitioner has a gatekeeper's role in the Dutch Healthcare system.

In the current Dutch situation none of the EHR market leaders seem to provide true interoperability (Spil et al., 2007). They conclude that stimulation of the suppliers by the government and end-users is needed to open up the market. To create a rationale for financial incentives of the government for EHR suppliers, three conditions must exist (Blumentahl, 2006): (1) the public must benefit, (2) market failure exists, (3) action of the state is necessary to correct market failure. An extended analysis of the market functioning of the Dutch EHR market is beyond the scope of this research, but we assume that market failures in the Dutch EHR market do not exist. For EHR suppliers to enhance data exchange, data standards and laws are found to be crucial and incentive alignments based on metrics are necessary (Yasnoff et al, 2004; Hersch, 2004).

The 4E-model (Collis et al., 2001) is adopted to unravel the deadlock situation. The acceptance of information systems is represented as a vector, which is the sum of four components: (1) effectiveness, (2) ease of use, (3) engagement and (4) environment. We assume that the needed value of the vector sum to pass the threshold as represented in figure 2, corresponds with the 'value' needed to break out of the deadlock situation. A possible gap between the vector sum and the threshold line can be seen as the gap between the current situation and the desired situation according to the EHR definition. The original 4E-model of Collis et al. (2001) is modified for reasons of applicability for this specific research in Dutch academic hospitals.

The definition of "Effectiveness" relates to support to the working process as well as to financial and other benefits for the end-user. The definition is best compared with the macro-relevance definition of Spil et al. (2004).The definition of micro-relevance is added to "Effectiveness", justified by the fact that Schuring and Spil (2003) found micro-relevance as a key factor in explaining IT-use. The component is renamed into "Relevance".

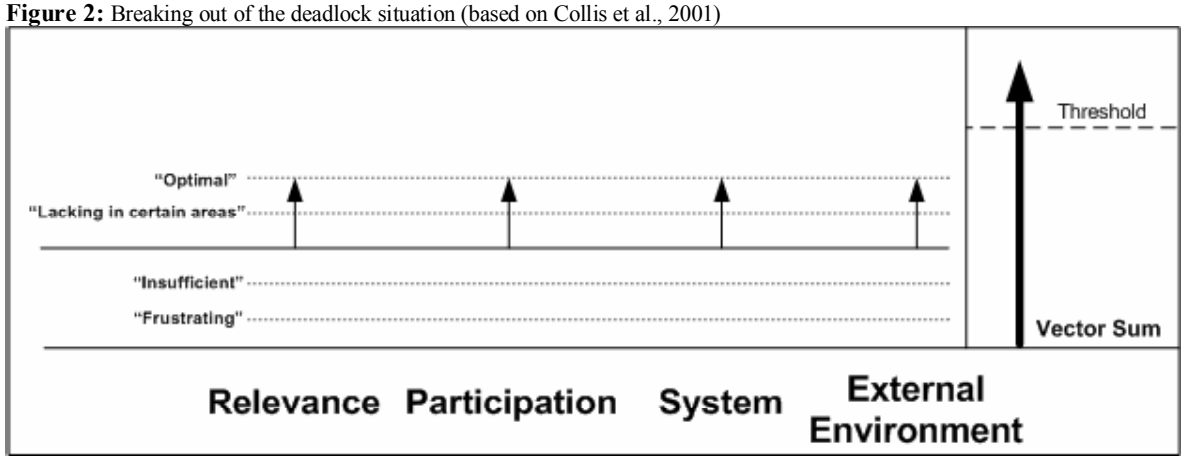
The "Ease of use" component in the model of Collis et al. (2001) is related to availability and usability aspects of the system. To indicate the system quality in this research we use the three system success categories according to the revisited approach of Delone and McLean (2002). Therefore the "Ease of use" component is renamed into "System".

In the original model "Engagement" is related to personal feelings and interest in computer systems. In this paper "Engagement" is described by participation as described in the former paragraph and by context specific characteristics of individuals (Leonard-Barton and Deschamps, 1988). We assume that these context specific characteristics of individuals influence the degree of participation. "Engagement" is renamed into "Participation".

The last component of the 4E-model, "Environment", consists in the original model of three items related to organizational aspects, technological developments and socio-cultural perceptions of the importance of technological developments. The definition used in the original model is best compared with external environment as used in this paper. The "Environment" component is renamed into "External Environment".

A scale ranging from "Frustrating" to "Optimal" is added to the original 4E model to improve the legibility. An important remark has to be made for our research, about dependency between components. From figure 1 we can see that relevance, participation (Katsma, 2007) and the system success dimensions Delone and McLean (2002) are interdependent. Despite the dependency between the components, the model will be used to expose lagging and progressive components.

Figure 2: Breaking out of the deadlock situation (based on Collis et al., 2001)



3 Research Method

In order to test our model as presented in figure 2, we decided to conduct case studies. Yin (2003) and Stoop and Berg (2003) have argued in favor of case studies for theory development. Data about hospitals and software vendors are collected in fifteen one-on-one qualitative interviews. Qualitative studies are capable of generating insights that can explain the effects of healthcare specific peculiarities (Stoop and Berg, 2003).

With the help of purposive or judgmental sampling (Babbie, 1995) four academic hospitals in the Netherlands were selected according to a specific set of criteria. These criteria include homogeneity of the hospitals, maturity of the EHR and the stage of the implementation progress. The implementation process should have progressed beyond 'go live' to be able to investigate the degree of adoption.

Table 4 Hospital selection criteria

Requirement	*Realization in this research*
Homogeneity of hospitals	each case is a Dutch Academic hospital.
Maturity of EHR solution	multidisciplinary implementation of the EHR
Progress of the EHR Implementation	the implementation process is progressed past going live for at least two specialties.

The homogeneity criterion incorporates the characteristics of an academic hospital: large organization, provision of education, and a high degree of medical technology adoption. Besides the characteristics, there is a strong cooperation between the branches of medicine of the Dutch academic hospitals.

Two EHR suppliers are selected by their presence in Dutch hospitals, the maturity of their EHR is equal or higher than level 2. One EHR supplier is selected because of the presence in 8 out of 9 academic hospitals. The second supplier has a market share of more than 26% in Dutch hospitals (Spil et al., 2007).

The empirical data is collected with help of extensive interviewing. In every hospital at least three distinctive different roles involved in the EHR project are selected (Trauth, 1997): supportive sponsor, project coordinator and key-user. This enables an investigation of the implementation process from multiple perspectives. The used interview model is based on the USE-IT model (Spil et al., 2004) and the 4E-model (Collis et al., 2001). The interview is structured according to the components of Figure 2. The relevance, participation and system questions are based on

the identified success dimensions as can be found in Table 1, Table 2 and Table 3 respectively. The questions about the external environment component are based on external influences as identified in the problem definition.

In Section 4 the qualitative data is translated for all cases into the modified 4E-model, which is developed for quantitative data. The cases are judged by comparing their empirical data with the identified success dimensions as can be found in Section 2. The current situation of the cases is drawn into figures, which shows the position of the hospitals relative to each other. In Section 5 the cases are compared with an analysis and the generic findings will be explained. Section 6 presents the conclusions.

4 Case studies

4.1 Hospital 1

4.1.1 Relevance at hospital 1

Two of the interviewees mentioned that 80% of the health records are still paper based. One of the interviewees indicated that a satisfying result from the introduction of electronic health records would be a decrease in the number of mislaid health records, for reasons of savings of time. The current administrative workload is perceived as high. All interviewees mentioned savings of time as a major point of desired improvement. The quality of care is expected to improve. Savings of time give the doctors the possibility to spend their attention to the patients instead of the EHR. Another mentioned perspective is the possibility to organize the care process more patient centered. In the current situation patients have to visit the hospital several times, because of a lack of availability of data. There is a lack of standardization and coordination between the care processes. The interviewees know how an EHR should support them in their work, but they do not expect the current EHR to do so. The interviewees expect future systems to gain relevance, but the macro and micro relevance of the current EHR is low in this hospital.

4.1.2 Participation at hospital 1

In order to engage end-users in the (future) decision process, an ICT priority board has been established recently, which determines the priorities of the ICT problems to be solved. The ICT priority board consists of doctors, nursing staff, and managers. Although the ICT department recently established the ICT priority board, the specialties in the hospital are autonomous; they are free to comply with the advices of the ICT department. Furthermore there is no structured way in which the key-users gather information from the end-users about the EHR. Several specialties do not want to wait until the ICT department decided which EHR will be used. However, they start their own initiatives without the coordination of upper management. In one of the specialties where a new EHR is initiated, the doctors who take the lead in the implementation process are doing this besides their regular work as doctor. There is no cooperation with the ICT department, nor with other specialties. They have the role of an IT-Champion, by braking through bureaucracy and the organizations rational investment, which underlie the system-development life-cycle (Earl and Beath, 1996). The ICT project leader stated that the culture in the hospital stimulates individual excellence of the doctor, while collaboration in the treatment of a patient is not stimulated. The management is not actively stimulating the end-users to use the EHR and there is no explicit quality requirement for the entered patient data.

4.1.3 System at hospital 1

The EHR at hospital 1 consists of a hospital wide EHR which is mainly used to store administrative information. Every specialty has its own EHR, which is not interoperable with the hospital wide EHR or an EHR of another specialty. The information quality therefore is lacking in completeness and the data accuracy is far from optimal since 80% of the information is still paper-based.

The system quality is perceived as bad; especially because of the slow startup time of the EHR. All interviewees agreed that the highest priority should be given to a hospital wide medication record and a short

summary of the medical treatment of the patient. Both functionalities are mentioned by the interviewees for reasons of quality of care improvements and especially patient safety improvements. All initiatives which lead to quality of care improvements and time savings are strongly recommended by the interviewees. Although all interviewees would like to have the opportunity to share data, discussions about authorizations do not improve the willingness to share all data throughout the hospital.

The ICT-department requires all new EHR's to be suitable for the current ICT-infrastructure. This requirement is unknown by the medical specialties and felt as a barrier to EHR innovations. An overwhelming amount of digital patient information is foreseen by the ICT-department. The overload of information (Tsiknakis et al., 2002) is making it impossible for healthcare professionals to distinguish critical from non-critical information.

4.1.4 External environment at hospital 1

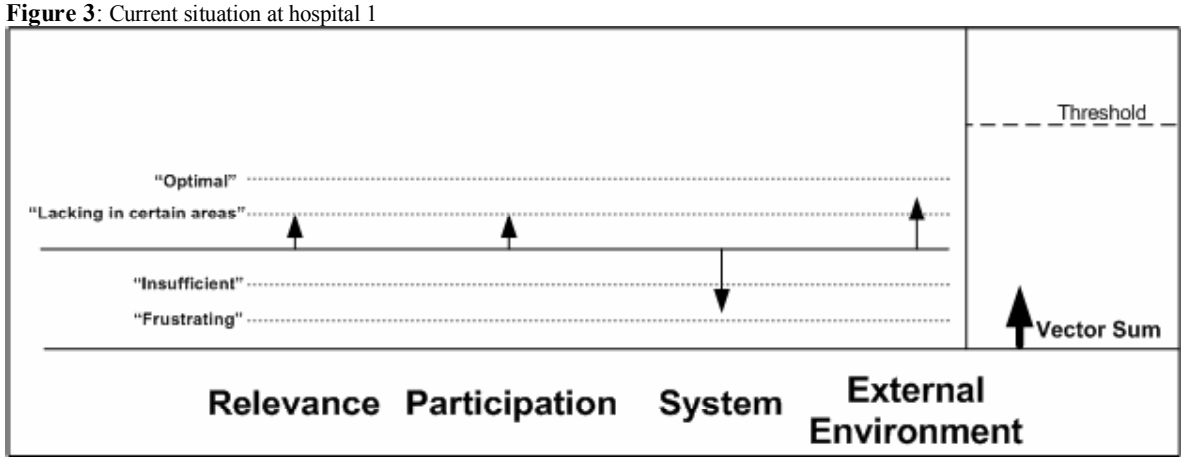
External influences which stimulate the use of an EHR are mentioned by two of the interviewees. The interviewees perceive growing pressure on healthcare professionals to record their treatment, for legal reasons. Closely related is the comment of one of the interviewees, who mentioned that recording the treatment is necessary to obtain the obliged certificates. The interviewees mentioned that an EHR could help them to record their treatment in a proper way. Digital collaboration with general practitioners is desired, mainly because of time savings. An interviewee from the ICT-department mentioned that medicine students should be trained in using an EHR, in order to solve adoption problems.

The interviewees did not experience pressure from the government or NICTIZ. One of the interviewees perceived the national wide EHR as a good idea, but the government should give financial incentives. A pressure is perceived from other hospitals: hospital 1 has the feeling that they are behind on track.

4.1.5 Current situation

Based on the findings in hospital 1, we can conclude that hospital 1 is below the threshold on all vectors. The current situation is drawn in Figure 3. The relevance of the current system in hospital 1 is judged as "Lacking in certain areas". There is a lack of standardization and coordination of care processes, but future expectations of an EHR are positive. Participation is judged as "Lacking in certain areas". The willingness of the specialties to adopt an EHR is positive, but the lack of management coordination is negative. The system component is judged worse than "Insufficient". The system quality is perceived as bad on all dimensions. The perceived pressure from the external environment to adopt an EHR is high and the component is judged better than "Lacking in certain areas". The Vector Sum is far below the threshold.

Figure 3: Current situation at hospital 1



4.2 Hospital 2

4.2.1 Relevance at hospital 2

In hospital 2 the EHR consists of a hospital wide EHR and specific EHR's for most of the specialties. From the perspective of the healthcare professionals, the availability of the system and the context in which the information is presented are mentioned to be most important, for quality of care reasons. Time savings are not expected by the interviewees, in fact electronic registration is perceived as time consuming. From the perspective of the ICT department and the hospital management, the integration of all different systems is mentioned to be most important. One of the key-users, whose specialty adopted a self-made EHR, mentioned that the hospital wide EHR is providing insufficient relevance, both macro and micro relevance. Albeit the criticism on the hospital wide EHR, the specialty is fully automated with the self-made EHR and does not need to share information with other specialties.

4.2.2 Participation at hospital 2

Medical specialties are autonomous in their EHR choice; they are autonomous in their choice to adopt the hospital-wide EHR or to adopt any another EHR. The empirical results show that the introduction is focused on the key-users, followed by the rest of the specialty. The management of the specialty announces the introduction of the EHR and at a certain moment the support for paper based records will be stopped. To support doctors for the initial additional administrative work, medicine students help with entering data into the electronic records. The healthcare professionals are trained in the use of the EHR. All end-users can upload their ideas for improvement into a digital suggestion box. From the empirical results we can see that the participation in the different specialties is good, but there is a lack of coordination between all different systems, which leads to a number of suboptimal EHR's.

4.2.3 System at hospital 2

The completeness of the information cannot be guaranteed with all different EHR's. None of the success dimensions from table 3 are considered by the interviewees to be good in the hospital wide EHR. The system is slow, it is not easy to use, the data is not legible, the system is not always available and the support is lacking. The negative evaluation of the system and the absence of customization possibilities for the highly heterogeneous needs were the main reasons for one of the specialties to adopt another EHR. The latter aspect and the bad cooperation with the EHR supplier were the main reasons for the specialty to build an EHR themselves, although they had to reinvent the wheel. The ICT-department recognizes these needs by mentioning that the hospital wide EHR should be improved by making it more intuitive and adding functionalities.

4.2.4 External environment at hospital 2

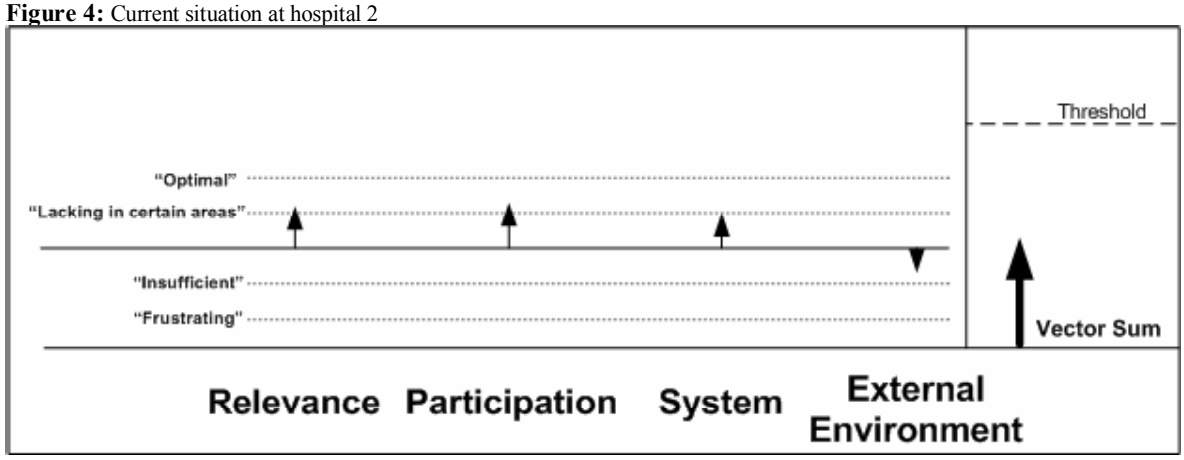
One of the interviewees mentioned that the rules of the government and NICTIZ are experienced as a restraining influence. Besides the rules, the interviewee mentioned that he would not benefit from a national interoperable EHR, so there is no reason for him to cooperate. The regional initiatives are mentioned to be of little importance for the hospital, since the hospital attracts patients from a wide area. The lack of importance from the regional initiatives, clarifies a need for a national EHR, which is not recognized by the interviewee.

4.2.5 Current situation hospital 2

The vector sum in the current situation of hospital 2 is below the threshold, as can be found in Figure 4. The electronic registration is perceived as time consuming and data is not available hospital wide. The relevance is judged slightly better than "Lacking in certain areas", because relevance for a single specialty can be high. Participation is judged better than "Lacking in certain areas". An EHR can be optimized for a specialty, but there is a lack of coordination. The system is judged as "Lacking in certain areas". The quality of an EHR can be high for a specialty, but completeness of information cannot be guaranteed with all different EHR's and the hospital wide

system is lacking on all dimensions. The absence of external pressure or even restraining external influence is responsible for the negative judgment of the external environment.

Figure 4: Current situation at hospital 2



4.3 Hospital 3

4.3.1 Relevance at hospital 3

The EHR in hospital 3 consists of a hospital wide self-made system. From the management perspective the manageability of the care process is the most relevant factor for an EHR introduction. The healthcare professionals mention the complete overview of the patient information to be the most relevant factor. Furthermore improved collaboration with colleagues and savings of time are mentioned to be relevant factors. For the latter aspect; saving of time is gained, because information can be entered once instead of several times throughout the hospital. One of the interviewees mentioned that the saving of time mainly accounts for the administrative department, while entering data is more time consuming for the healthcare professionals. An interviewee mentioned the availability of medical knowledge as a relevant factor, since he works in an academic hospital.

4.3.2 Participation at hospital 3

In hospital 3 the EHR implementation is coordinated by the executive board. The ICT-department cooperates with the middle management of the specialties. The interviewee mentioned that the lower management has too little power and the upper management of a specialty is too inflexible. New EHR parts can be initialized in three ways: (1) out of the hospital EHR strategy, (2) via end-user wishes and (3) via the functional control department. When a new EHR part is introduced, end-users can give their comments and after a short time there will be an update, trying to gratify the user demands. Although the EHR is developed with the restriction that a doctor should be able to acquire the needed skills to use the EHR within 3 minutes from a colleague, the ICT-department is creating a digital EHR learning environment. The digital environment should stimulate self-confidence of healthcare professionals to use the EHR.

4.3.3 System at hospital 3

The vision from the ICT-department is that healthcare professionals should benefit from all data entered into the system. The ICT-department spends a lot of time to improve the ease of use of the system. Their principle for the ease of use is: “don’t make doctors think”. An interviewee from the ICT-department mentioned that the speed of the system is a very important for reasons of savings of time. Another interviewee mentioned that the network capacity is reaching its maximum, because of the enormous growth of data traffic, mainly caused by x-ray and MRI images. The reliability is not optimal. Because of the lack of reliability of the system, it necessary for the specialty to keep

paper based back-ups. Furthermore, shortages in the system are causing inefficiencies in the working process of the healthcare professionals. The interviewee of the ICT-department mentioned that the ability of the EHR to deal with use cases of every specialty is a very critical and concurrently one of the hardest factors of implementing an EHR.

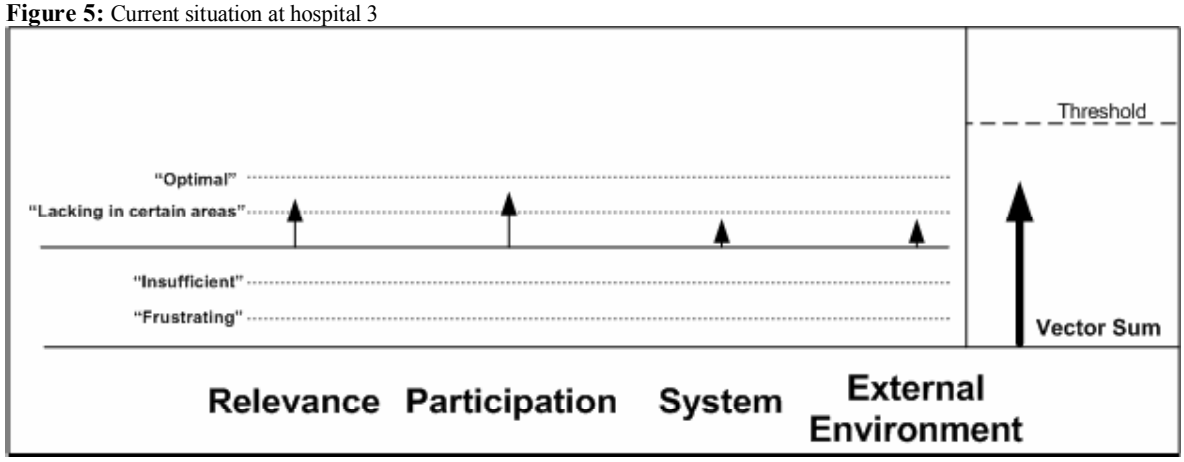
4.3.4 External environment at hospital 3

The external environment influences the use of the EHR for several reasons, according to one of the interviewees. The EHR has to be used for reasons of declaration in the first place, since the government introduced the DBC declaration structure, comparable with the Diagnostic Related Groups (DRG). One of the interviewees mentioned that the tendency towards more transparency of performance indicators stimulates healthcare professionals to register their treatment in the EHR. Junior medical doctors can use the EHR to prove that they met medical criteria, i.e. they have done a certain number of operations, which is required to obtain a certain certificate. Furthermore there are initiatives with patient communities, where patients and healthcare professionals can share information in a digital environment. The ICT-department has taken the requirements of NICTIZ into account, with the development of the system, but priority is given to the internal optimization.

4.3.5 Current situation hospital 3

The current situation in hospital 3 is presented in Figure 5. The relevance factor is judged better than “Lacking in certain areas”. The information is available hospital wide and collaboration with colleagues is improved. On the other hand it is perceived that the saving of time mainly accounts for the administrative department instead of the healthcare professionals. The participation in hospital 3 is judged better than “Lacking in certain areas”. There is coordination from the management board and management is focused on early adopters. Shortages and lacking reliability are responsible for the judgment worse than “Lacking in certain areas”. The hospital is taking the national initiatives into account and external advantages are mentioned, but it is not perceived as a big pressure. The external environment component is judged worse than “Lacking in certain areas”. The hospital is still below the threshold.

Figure 5: Current situation at hospital 3



4.4 Hospital 4

4.4.1 Relevance at hospital 4

The EHR in hospital 4 consists of a hospital wide EHR and specific EHR’s for most of the specialties. Three out of five interviewees mentioned the saving of time being the most relevant factor. One interviewee mentioned the uniform registration as most relevant factor. The last interviewee mentioned an improvement in the quality of care, because the EHR helps the healthcare professional to make medical calculations, which has not always been done

before. It was emphasized by one of the interviewees that not all information should be shared. There is a risk of interpretation errors, because not all healthcare professionals can interpret all information in the right way. A group of representatives of all specialties has determined a set of patient data, which should be available hospital wide.

4.4.2 Participation at hospital 4

In hospital 4 medical specialties are autonomous in their EHR choice. All interviewees mentioned that early adopters are actively involved in the EHR selection process for their specialty. One of the interviewees mentioned he felt insufficient support from the management board, since he had to invest his own free time in the EHR implementation. Two interviewees mentioned that the management board should make a choice for an EHR, because of all different EHR activities leading to suboptimal solutions. Two specialties developed their own EHR and are fully automated. The reason for the two specialties to develop an EHR is the negative evaluation of the hospital wide system. The implementation at the two specialties started with a small number of early adopters, which could criticize the EHR. After fixing the teething troubles, all healthcare professionals were forced to use the EHR by stopping the support for paper based records. The self-made EHR of the two specialties will be implemented at more specialties.

4.4.3 System at hospital 4

The EHR can be divided into the old hospital wide EHR and the self-made EHR. The service quality of the hospital wide EHR is mentioned to be sufficient by two of the interviewees. The system- and information quality of the old system are mentioned by all interviewees to be lacking; one interviewee stated “I have to walk to another part of the hospital to be able to enter my data”. Two of the interviewees, who are using the self-made EHR, were positive about the completeness and legibility of the EHR. All workplaces were equipped with dual screens, to be able to have a complete overview of the patient. The ease of use and the workflow support were mentioned to be important success factors of the system. All interviewees mentioned customization possibilities as an important success factor for an EHR.

4.4.4 External environment at hospital 4

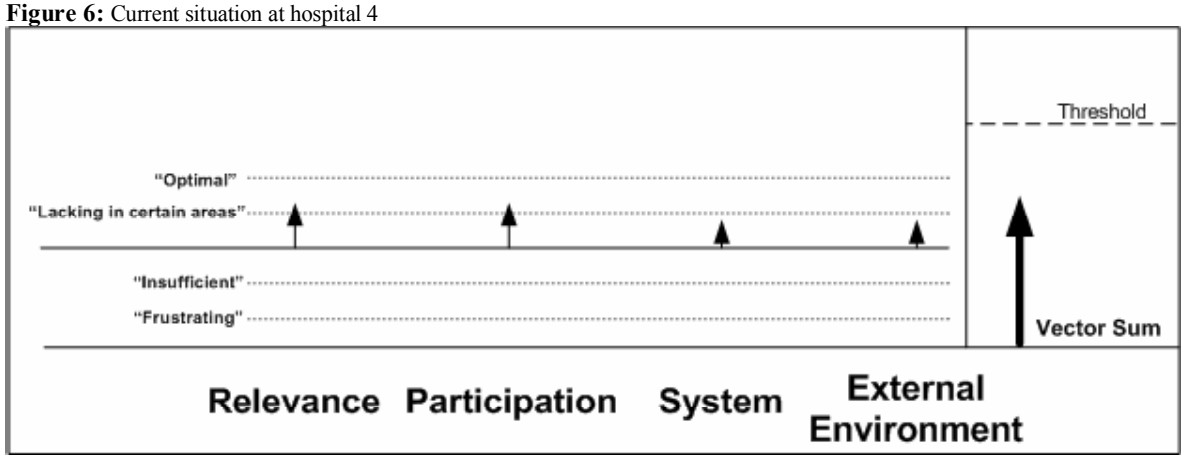
The pressure from the external environment to adopt an EHR is felt by four of the interviewees. One interviewee mentioned that external pressure to record the treatment already existed, so an EHR does not change that pressure. Legal aspects, benchmarking, evidence based medicine and more transparence of quality indicators are felt by the interviewees as pressure to adopt an EHR. There is a regional initiative to connect general practitioners to the hospital, which is important for the quality of care, according to three of the interviewees. One interviewee mentioned that he felt pressure from his patients to adopt an EHR. The national initiative does not positively influence the adoption decision, according to all interviewees. According to three interviewees, exchanging patient data with other hospitals is not relevant. The hospital should create a hospital wide interoperable EHR before investing in a national wide EHR.

4.4.5 Current situation hospital 4

The current situation at hospital 4, as presented in Figure 6 shows that the vector sum is below the threshold. Regardless of the high relevance for specialties with a self-made EHR, they do not represent the complete hospital. A set of data, which should be available hospital wide has been determined. However, it is not available in the current situation. Not all specialties are willing to share their data, because of the risk of interpretation errors. This risk is due to a lack of medical vocabulary and a lack of standard care processes. The relevance is judged better than ““Lacking in certain areas”. The participation of a self-made EHR can be good for a specialty, but is not representative for the hospital in total, although plans are being made to implement the self-made EHR hospital wide. The participation is judged as better than “Lacking in certain areas”. The lacking system and information quality of the hospital wide system are responsible for the judgment worse than “Lacking in certain areas”. Legal aspects, benchmarking,

evidence based medicine and regional initiatives, which connect general practitioners to the hospital, are positively influencing the adoption decision, but national initiatives do not. The external environment is judged as worse than "Lacking in certain areas".

Figure 6: Current situation at hospital 4



4.5 EHR suppliers

An important remark has to be made about case 3, where the EHR consists of a self-made EHR and case 4, which consists partially of a self-made EHR. This paragraph is about external EHR suppliers instead of self-made EHR, therefore this paragraph does not reflect these cases. The ICT-departments of case 3 and 4 can be considered as internal EHR suppliers.

4.5.1 Relevance

From the perspective of the EHR suppliers relevance for the healthcare professionals is gained by savings of time and ease of use. Efficiency is not measured, but claims are made that the EHR is capable of saving time. The two mentioned elements correspond with the elements of system quality, as identified in Table 3. One of the interviewees stated that "doctors should be made aware of the fact that the EHR is in favor of the hospital, which is indirectly in favor of the doctor". This statement indicates a lack of macro-relevance for the end-users.

4.5.2 Participation

According to one of the interviewees academic hospitals are behind on track in comparison to non-academic hospitals in the Netherlands. This is due to the size and complexity of the organization and because academic hospitals stick to their old ICT infrastructure.

On the medical specialty level, participation is found to be higher with self-made systems than with systems from EHR suppliers. This is due to the ability of self-made systems to adapt to the working process of the healthcare professionals and the agreement among end-users about the data which need to be shared. This agreement is more difficult to accomplish on a hospital wide level. External suppliers' EHR's are developed with the intension to fit for all different working processes of the hospital. This requires end-users to adapt to the system, which in turn leads to end-user resistance.

4.4.3 System

One of the interviewees mentioned that it is important to make a distinction between predictable and unpredictable care. An EHR is capable of supporting the workflow of predictable care, while it is not for unpredictable care. For unpredictable care it is very important for the information quality that an EHR supports maximum expression power. The strength of an EHR is its ability to adapt to unexpected events. A precondition for the ability to adapt to

unexpected events is the total situational awareness of events of the system; therefore information input is needed throughout the complete care process.

The information quality dimension from Table 3 and especially the completeness of the information is mentioned to be important by the interviewees. One of the interviewees acknowledged that the legibility, and by that the accuracy of the information, is threatened by the risk of data overload. This risk is controlled by the option of filtering data.

4.4.4 External environment

The most important factor to stimulate EHR adoption, is the Dutch reimbursement system, which forces hospitals to register electronically. There is no direct need for a national wide EHR according to one of the interviewees, because of interpretation errors among the different care providers. The possibility of interpretation errors is due to a lack of a standard medical vocabulary. The EHR suppliers believe that the healthcare market as a whole is able to benefit. However, hospitals might be reluctant to share their information on a national level, because it is uncertain if they will benefit.

5 Analysis and Discussion

5.1 Relevance

No big differences were found between the four academic hospitals regarding the expectations of an EHR. Differences on the micro-relevance level are caused because of differences between the degree of EHR implementations and the way EHR's are implemented. The latter aspect will be elaborated in the next paragraph.

Nearly all interviewees mentioned the savings of time as most important macro-relevant factor. Most interviewees mentioned that savings of time mainly account for the administrative department. Only those interviewees, from whom the complete specialty is organized to work with the EHR (Georgiou et al., 2005) mentioned to work more efficient. The automatic generation of letters mainly accounts for the savings of time for the end-users. From all data entered into the EHR the necessity should be clear to the end-users and preferably end-users should be visibly rewarded for entering the data. Identified factors which can leverage relevance for end-users in order of priority are:

- savings of time
- availability
- organization of patient centered care
- support of care provision (automatic calculations for medical profile)
- uniformity of registration
- manageability of care process
- access to scientific data.

The priority of the items showed above is determined by totaling the times an item is mentioned by the interviewees. Although financial incentives were identified in Table 1 none of the interviewees explicitly mentioned that these incentives will leverage the rate of EHR adoption for them personally. Adequate funding is necessary for implementation success (Bostrom et al., 2006), but from both end-users' and suppliers' point of view seen as inadequate.

5.2 Participation

A tendency towards the adoption of self-made EHR's was found in three hospitals. In all three cases the main reason for a specialty or the complete hospital to adopt a self-made EHR is absence of customization possibilities for the highly heterogeneous needs. End-users are getting actively involved in the learning and experimentation process of

the self-made EHR implementation. In all three cases early adopters are actively involved in the implementation process, although no structured way of communication between key-user and end-users before an implementation is found in one of the cases. A positive relation between self-made systems and participation of end-users is found, because the self-made system is able to support the workflow, like a third grade EHR is supposed to.

In three out of four hospitals we see a lack of top management involvement in the EHR adoption process; the specialties are autonomous in their choice for an EHR. When looking at the conflict management dimension from Table 2, we see that decisions do not lead to one direction. Top management involvement is widely recognized to positively influence end-user acceptance (Weiner et al., 1997; Davis and Wilder, 1998; Umble et al., 2003). Specialties are optimizing their own department, with or without self-made EHR's, but in all cases without considering the effectiveness for the hospital. Suboptimal EHR's lead to suboptimal care for the individual patient (Chen et al, 2007).

A precondition for a successful hospital wide EHR implementation is the modeling of workflows. Workflows have to be modeled in such a way that they maximally contribute to the hospital's goals. From cases 2 and 4 we can see that workflows are optimized for one specialty, but workflows have to be optimized for the complete hospital to contribute maximally to the hospital's goals. To justify the changes in the workflow, it is necessary to define business cases and stipulate the revenues to the end-users (Sutherland and van den Heuvel, 2006). The EHR has to adapt to the optimized workflow.

5.3 System

Before the EHR breaks through the threshold, all success dimensions of the system are already threatened. The information quality is threatened by a potential overload of information, which makes it impossible to separate crucial from non-crucial information. The system and service quality are threatened with overuse, like in case 3, which negatively influences the speed and availability of the system. An important precondition therefore is sufficient capacity of the EHR. Reliability is found to be crucial for specialties to go fully digital.
The found success dimensions in order of priority are:

- reliability
- completeness
- legibility
- expression power
- workflow support
- speed of the system

In all cases, independent from the system success factors as identified in Table 3, we found complaints about too little power to express. An antagonism between narratives and structured data entry exists, both having advantages and disadvantages. Medical data entry has to fit within data processing for e.g. reimbursement or scientific research, but also has to fit within the daily practice of the healthcare professional. As already stated in the introduction, the EHR emerged from supporting the back-office processes towards support of the front-office processes. Shift of focus from back-office to front-office is necessary to support the work of the healthcare provider. Self-made EHR's which are made in close cooperation with the healthcare professionals succeeded in this shift.

5.4 External environment

The external environment is found to consist of four levels: national level, regional level, hospital level and specialty level. On the national level we can distinguish the initiatives of NICTIZ and the perceived pressure from the healthcare market. The NICTIZ initiatives are found not to leverage EHR adoption. Most interviewees acknowledge that the healthcare market as a whole is able to benefit from a national EHR, but they do not perceive personal benefits. The government should make clear in what way end-users can benefit. Case 1, the hospital which is back on track, is perceiving pressure from the external environment of the healthcare market. A plausible explanation for this

perceived pressure at the lacking hospital is that they were not able to see the benefits of an EHR and decided to defer the adoption decision as long as possible. In the current situation they see the EHR adoption as an industry trend and feel the pressure to adopt an EHR (Kuan and Chau, 2001). Other identified factors which can leverage the adoption decision in order of priority are:

- quality certifications
- transparency
- benchmarking possibilities
- patients.

The quality certifications are perceived as a pressure to adopt an EHR. The EHR can help doctors to prove that they performed a certain number of required surgeries. Transparency of performance indicators is found to positively influence the adoption decision, although there are critical notes about the value of performance indicators. Performance indicators might mislead the public about the quality of the hospital (Aron et al., 1998). It is remarkable that just one interviewee mentioned to feel pressure from his patients to adopt an EHR. Although initiatives which stimulate contact between healthcare providers and patients are found to gain macro-relevance for the healthcare providers.

On the regional level, the contact with the general practitioner is found to leverage EHR adoption, mainly because of savings of time. The contact between hospitals does not gain relevance, because of possibilities of interpretation errors, due to absence of a standard medical vocabulary. The lack of interplay between specialties and in three out of four hospitals can be found in the Participation section.

6 Conclusions

The deadlock situation can be described as a discrepancy between the expected outcome of an EHR and the effort to reach it. None of the hospitals broke out of the deadlock situation.

There is a high level of agreement among all respondents in their perception of relevance. Savings of time and availability of data are found to gain relevance the most. The relevance perception differs from non-academic hospitals, where the relevance perception is more on quality of care incentives. The reason for this difference can, in our opinion, be found in the stage of EHR implementation and the organizational structure of the academic hospitals. Academic hospitals are found to be behind on track in comparison to non-academic hospitals.

The management coordination is lacking in three out of four cases. In these three cases the specialties are putting their effort in optimizing their own EHR, without considering the complete hospital. The optimization per specialty without management coordination, leads to suboptimal systems and is bounded from above by the threshold as presented in Figure 2. Our model is able to expose the lacking and progressive factors of an EHR implementation, however further research should expose the interdependency between the factors of the model.

Participation of end-users is higher when using self-made EHR's compared to EHR's of external suppliers. The self-made EHR's are able to adapt to the workflow of a specialty. Case 3 shows that the self-made EHR is a victim of its own success. In our opinion the tendency towards self-made EHR's is not in line with the outsourcing policy of hospitals and hospitals are not organized as software suppliers. Further research is necessary to investigate the service quality of self-made EHR's.

Standardization and optimization of workflows throughout the hospital are needed for a successful EHR implementation. Healthcare professionals have to be convinced with help of business cases, to justify changes in their workflow. In three out of four cases EHR's try to gain relevance with additional functionalities, whereas availability of basic medical data can improve quality of care. Especially hospital wide availability of medication data is mentioned to leverage relevance.

On a regional level efforts should focus on improvements on the cooperation between hospitals and general practitioners. The national wide EHR initiative does not leverage relevance. Agreement among healthcare professionals about the data set, which need to be shared and agreement about standard medical vocabulary are preconditions for a successful national wide EHR. Thereby NICTIZ has to stipulate the benefits for the end-users in the hospitals, as the end-users perceive to not being the ones who benefit.

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