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A case study of an EMR system at a large hospital in India: Challenges and strategies for successful adoption

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ABSTRACT

This paper presents an ethnographically inspired interpretive case study of the Electronic Medical Record (EMR) system at Sankara Nethralaya hospital in India. It presents challenges related to the adoption of the system and methods and strategies that were utilized in order to overcome these challenges and help the system be adopted successfully. One of the more notable challenges at the hospital was a user base that included skeptical users, those lacking computing skills, and that had a history of rejecting designs. Despite these barriers the hospital was able to adopt the EMR system successfully. Notable issues related to the success of the system include the design strategy that was eventually used, and critical technical and social features of the system intended to support skeptical users and those lacking IT skills. The study contributes to overall understanding of the environment at large hospitals in developing countries as it relates to the adoption of EMR systems, and helps inform on methods that can be used to improve the adoption of EMR systems in similar contexts in both developed and developing countries.

1. Introduction

Electronic Medical Records (EMRs) are expected to provide a wide range of advantages to healthcare providers [1–3]. The health sector is still far behind many other areas of society in the adoption of Information Technology (IT) however [4]. EMR systems are no exception in this regard and are challenging to adopt in practice.

A contributing factor is that healthcare organizations are complex and include a variety of complicated work practices [5,6]. This includes strong interdependency on roles, and a hierarchy of distributed responsibilities. This interdependence can make imposing changes difficult because a small change in one person's workflow may affect the performance of someone else's workflow [7]. Medical Informatics Systems (MIS) for such hospitals can thus be challenging to design and implement, and nearly half of them fail due to user and staff resistance [8].

Studies employing methods adopted from Computer Supported Cooperative Work (CSCW) have been suggested in order to improve socio-technical understanding related to this complexity, and ultimately lead to better designed MIS systems [9]. Knowledge obtained from organizations that have already adopted MIS systems is also viewed as particularly valuable as input [10].

There is a general lack of studies however that report on EMR systems that have been successfully implemented at large hospitals in developing countries. Most relevant studies on EMR systems that have been published are from developed countries [11–15]. ICT solutions for developing countries often require a different approach than is used in developed countries however [1,16]. Organizational and user needs can be different due to cultural factors, and issues such as a lack of computing skills among staff may complicate adoption. A few notable studies have been conducted on EMR systems for developing countries [1]. None of the systems however have been implemented at a large hospital.

Another challenge is that there is a lack of available studies that report on design strategies for EMR systems in general. Although usability has been acknowledged as a critical aspect of overall system design [11], existing studies of EMR systems have focused much more on the implementation process [11,17] than on the design process.

This lack of studies complicates efforts for those attempting to design EMR systems in developing countries. Participatory Design (PD) for example is a technique commonly used in designing MIS systems and is based on utilizing two-way dialog between designers and users during the design process. Depending on how it is conducted it can give users a high level of control over the final product that is implemented.

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Few studies that report details on the usage of PD during the development of EMR systems have been reported however. A study of an EMR system at an acute stroke unit in a Danish hospital being a notable exception [18]. It is unclear however how this study reflects on what can be expected when attempting to utilize PD in developing countries. This is because PD is considered to be a framework instead of a specific protocol. Adaptations must be made to each unique situation, and studies reported experiences from one workplace culture, such as a Scandinavian workplace including labor unions, can be difficult to transfer into another workplace culture [19].

These issues illustrate the many unclear challenges related to the adoption of EMR systems at large hospitals in developing countries. Complexities that may be encountered related to the organizational environment and user needs are unknown, and methods and strategies that have been used to overcome these challenges and meet these needs have not been reported.

This paper addresses this issue. An interpretive case study from a large eye hospital in India that has adopted an EMR system is presented. Some of the key challenges the hospital faced in trying to adopt the system include a fairly complicated organizational climate that included a wide range of expectations from the system from various stakeholders, and difficulty in identifying the correct design strategy. This resulted in users rejecting the first few versions of the system. In order to overcome these challenges an extensive (and novel) version of PD was utilized. This process, together with the inclusion of several notable technical and social system features targeting skeptical users and users lacking computing skills, eventually helped the hospital overcome these challenges and adopt the system successfully.

Together the issues presented contribute to overall understanding of challenges that may be encountered when adopting EMR systems at large hospitals in developing countries, and methods and strategies that can be used to overcome these challenges in similar contexts, (i.e. large hospitals including skeptical users and/or those lacking IT skills) in both developed and developing countries.

2. Background

The successful adoption of MIS systems at complex organizations requires an alignment between the system functionality and the needs and working patterns of the target organization [20]. This often requires a socio-technical approach [21,22,9] and system design that is adapted specifically to the organization [23]. This customization not only includes technical aspects of the system but also social features in the form of organizational changes [22]. These features need to support each other, and need to be developed iteratively.

There are a number of factors that make such custom built EMR systems difficult to adopt. An issue well established in CSCW theory is that varying expectations from various users can lead to systems that create a disparity between those who benefit from the system, and those who do additional work to support it [23]. This can lead to system failure.

This issue also is reflected in studies of EMR systems. Managers tend to view EMR systems as facilitators of organizational change for example, whereas clinicians view them more as facilitators of the documentation process [12]. These different views can cause problems in trying to realize the original goals for adopting the system [12].

Suggestions have been made in order to deal with this issue by making sure that the impacts of the system are considered in the context of different stakeholder groups [2]. While this may seem intuitive it is an issue that is sometimes overlooked. The additional work incurred by those that input data in the clinical context in order to support non-clinical benefits for example, may not always be considered when adopting them [24,25].

Studies from developing countries have also noted a wide variety of both clinical and non clinical reasons for adopting different EMR systems. These reasons are not identical for each system that has been implemented and include issues such as research, clinical use, and easier reporting of aggregate statistics [1]. A picture of the overall expectations and interests that can affect the adoption of EMR systems at large hospitals in a developing country, and ways to help meet these expectations, could thus be of value, as it is unclear as to how complex of an environment can be expected and how to approach the adoption of system for this unknown complexity.

There are also a variety of other issues related to the adoption of EMR systems that may present challenges in developing countries. Some concrete attempts have been made to generalize issues that may cause a specific implementation to fail or succeed based on the available case studies [15]. This noted *"Previous computer or EMR experience"* by staff was noted as a critical issue for successful EMR implementation [15]. Health staff in developing countries however will often have less experience using computers than those in the developed world. Methods that can be used to overcome this problem could thus be of value to help the adoption of EMR systems in developing countries.

As noted in the introduction, another issue is that design strategies have not been well reported for EMR systems in general. A related issue, is that PD as it is often practiced within healthcare has been noted as too reliant on external designers [36]. This can make it difficult to meet evolving needs of organizations since external designers generally do not provide enough design resources over time.

This issue seems particularly relevant for the successful adoption of systems in developing countries since the creation of systems that are operationally sustainable, and thus do not rely on outsiders for support beyond the start up phase, is noted as a highly relevant problem [26]. With respect to EMR systems a key challenge with this perspective is thus how to approach the task of helping the hospital become experienced enough to succeed at such 'self-centered design' processes after any external design team has left.

3. Method

An ethnographically inspired interpretive case study was conducted at Sankara Nethralaya (SN) eye hospital in the Indian metropolitan city, Chennai, in the state of Tamil Nadu. The study was conducted in order to investigate a hospital in a developing country where an EMR system had been adopted. It was conducted by an Indian medical doctor with the intent of informing the Indian medical community on issues that may aid in the adoption of EMR systems in similar settings. Some of the specific topics of interest before the study was conducted were the expectations for the system from various actors in the hospital, challenges the hospital faced during its adoption, and strategies that the hospital used to overcome these challenges.

SN was selected for the study because it is a large hospital with a strong reputation, and because they were in the process of implementing the EMR system when contacted about the study, and thus was still using paper and electronic records. This provided the opportunity to allow knowledge about the EMR system, and also about the ongoing implementation process, and issues related to the transition between the two systems, to be obtained.

Data was collected during a 53 day period from 12th Nov 2007 to 4th Jan 2008. The data was collected using observations,

semi-structured interviews, informal conversations and documents. These documents included the hospital's web site and paper and electronic versions of the health records used at the hospital. Some additional follow up information was also obtained by email correspondence with contacts at the hospital after the formal data collection period was finished.

3.1. Observations

Observations yield best results when conducted by an outsider with considerable inside experience [27]. For this study the observer (the second author) was a medical doctor with 5 years previous experience working in a hospital (not the hospital where observations took place) as a physician. The observations were conducted in 3 phases for a total of 80 h. Short observational periods of this type can be extremely useful in a design context when conducted appropriately [27].

General observations of the operation and work situation at the hospital were conducted in addition to observations focusing on specific work roles and locations that were deemed to be interesting during previous observations.

The *first phase* of observations was conducted to help the observer get an overall idea of the organization and structure of the hospital. During the first week in the hospital the observer became acquainted with the different departments and also gained general information about how patient records are created, and who enters information into the EMR and paper records. Observations were also made at the reception desk in order to gain general information about the reception area. The observer took general notes about the hospital and also took photographs to use for later reference.

This was followed by 2 additional phases of observations that followed the steps that a patient goes through at the hospital. This included cabins where patients meet with optometrist and where they receive consultation from an ophthalmologist (referred to as consultant for the rest of the paper).

During the *first phase* of observations it was revealed that 60 to 70% of patients' information entered into medical records is done so by optometrists. The bulk of observations focusing on specific a work role thus targeted the optometrists' routine work.

During the *second phase* approximately 30 h of observations were conducted with twelve different optometrists. Permission was granted by the head of department to conduct observations inside the optometrists' cabin. This required the observer to create social contact with the optometrists. This social contact was obtained by having the Head Optometrist introduce the observer to the optometrists.

Attempts were made to have minimal influence on the work practice of the optometrists during observation. The optometrists were told that the observer had arrived from Norway in order to observe how eye hospitals in India function. The optometrists were not told about the specific purpose of the observations in order to avoid influencing the way they used the EMR system. They were also not told that the observer was a medical doctor, as there were concerns that this may have influenced their work due to the strict hierarchy in the hospital between doctors and optometrists.

The optometrists were engaged in discussions about general issues such as workload, and later also asked questions related to the EMR system, such as why they have a computer in their cabin. Notes were collected regarding interesting observations and comments by the optometrists, and other issues that made an impression [28].

The *third phase* focused on observations with consultants. 10 h of observations were conducted with five different consultants. The medical background of the observer helped him to mingle with them easily. In the beginning there were some reservations since the consultants were unsure exactly what the observer was seeking information about. Once they understood however that the observations were related to use of the EMR system, and not their competence of treating patients, they were open and interested to discuss issues related to the EMR system. Many of the consultants became so interested in the study that they often tracked the observer down to share information when the observer was in another cabin.

3.2. Semi-structured interviews

Thirty semi-structured interviews were conducted in English with 21 different actors, including hospital managers, IT staff, health staff and an employee of the vendor (a former-employee of the hospital) of the EMR system who is the project leader for developing the EMR software. Interviews lasted from 20 to 60 min, for an average of 40 min per interview. Approximately 21 h of interviews were conducted in total. The details of the interviews are contained in (Table 1).

Thirty interviews were conducted with 21 different actors. Some participants were interviewed two or three times in order to clarify information deemed to be interesting during their initial interview. All interviews were recorded except one interview with a consultant that requested his/her interview not to be recorded.

The interviews were conducted face-to-face by the same person that conducted the observations. The interviews began with the interviewer introducing himself and elucidating the purpose of study. Confidentiality and privacy of the participant was ensured. After consent was given an appointment for conducting the interview was made for a time convenient to the participant. Apart from semi-structured interviews informal talks/conversations especially at lunchtime or tea break also occurred. Such informal talks proved quite informative because participants seemed relaxed and more open.

All the interviews were transcribed by a professional transcriptionist and were verified by cross checking. Eighty-three pages of transcribed material were produced from recorded interviews. Transcribed material was read thoroughly back and forth.

Initial analysis of the interview data was conducted by the person that had conducted the observations and interviews. The goal of this analysis was highly related to the original goals of the study. Attention was given to identifying issues that had promoted or hindered the adoption of the system, and the strategies utilized by the hospital to help it be adopted successfully. Factors favoring or hindering the adoption of the EMR system were highlighted and common topics or concerns expressed by the participants were given priority.

The results of this analysis were then discussed with an HCI/CSCW researcher (the first author) and this person reviewed the results of the analysis independently. The two researchers engaged in continuing discussions and developed common themes that were used to conduct further analysis. These themes were selected

Table 1
The interviews conducted during the study.

Actors	No.	No. of interviews
Managers	5	11
Chairman	1	1
Medical Superintendent	1	2
Medical Record Department	1	3
Hospital IT Director	1	2
Head Optometrist	1	3
Consultants	5	7
Optometrist	10	10
Vendor	1	2
Total	21	30

to help develop connections between issues identified during the first round of analysis, and thus build a better overall picture of the situation at the hospital as it related to the adoption of the EMR system. The themes selected were the *organizational environment* (including interests and expectations for the system), *design history and strategy*, and *critical technical system features and critical social system features* that helped the system be successfully adopted.

These themes were also deemed as useful in order to incorporate a CSCW-oriented perspective into the analysis, where understanding of organizational issues, use of the appropriate design approach, and eventual inclusion of the correct system features, are viewed as crucial for creating a system that can be successfully adopted in practice [29]. In this respect the themes are highly related to understanding issues that affect the adoption of systems, and methods and strategies that can be used to improve their adoption, before, during and after implementation of the system. Some limitations related to the quality of the data were encountered with respect to details of the design method. This was because the study took place after most of the design process had been conducted and because the person that conceived the study and collected the data did not have a design background, and thus did not inquire deeply into these details. The data that did exist was still deemed to have value however, as it provided some details on how the design strategy aided the successful adoption of the system. An additional limitation in analyzing the data was encountered due to partial data loss that occurred after the analysis presented below had been conducted. It was thus not possible to further refine the data analysis in order to create useful tables to, for example, further summarize the findings and/or flesh out some of the more interesting issues that had been identified.

Notes from the observation data were not formally merged with the interviews during this analysis process. Instead the observations helped to guide the interview process by allowing them to be conducted after the interviewer had developed understanding about the overall hospital environment as it related to the EMR system.

4. Results

This section is organized around the four themes, organizational environment, design history and strategy, critical technical system features and critical social system features. The organizational environment subsection informs on the general environment at the hospital in order to ground the overall study in the understanding of this environment. It also provides insight into some of the key challenges that the environment presented with respect to the EMR system, including varying expectations for the system from different actors and a challenging user base. The design history and strategy subsection is related to both the challenges the hospital faced in adopting the system, and in strategies that helped overcome these challenges. This is because identifying the correct design strategy proved to be a great challenge for the hospital, and the eventual utilization of the correct design strategy was a key to success. Finally, the critical system features subsection describes specific aspects of the EMR system that helped meet the needs of users identified in the earlier subsections. This includes both social and technical aspects of the system.

4.1. Organizational environment

SN is a large tertiary hospital specializing in ophthalmology. Each day it serves approximately 1200 patients and performs 100 surgeries. The main hospital contains 17 departments and sub-specialties. Patients are received directly at outpatient clinics and also on referral from other hospitals. Each of the sub-specialties has their own wards where they admit patients treat them and discharge them. In addition to treating patients at this main facility (the location where the study took place) SN treats patients at 5 satellite clinics in the Chennai area, and at a hospital in Calcutta.

The organization of SN is very hierarchical and managers hold a considerable amount of power. There are no labor unions, or formalized mechanisms to ensure job satisfaction or security for workers beyond keeping their superiors satisfied with their work production. Clinical staff are generally focused on day-to-day work and do not generally engage in discussions around strategic ways to improve the hospital or their work environment.

Because SN is located in an Indian metropolitan city it is a fairly crowded place. (Fig. 1) shows a picture of a crowded waiting room at SN full of patients waiting to see a consultant.

4.1.1. Challenging users

One of the key social issues that made adopting the system a challenge was that *many of the staff were reluctant to change, and in some cases had little or no previous experience using computers*. Two of the 10 optometrists interviewed noted that they did not have any computer experience before the system was implemented. One of the managers explained,

> "We have mixed generations of staff; it is easier with younger and newly employed staff, it was not easy to convince senior consultant to train and make them to use system. They are used to paper based practice since last 20 to 30 years..." (Manager_4 Dec. 2007)

4.1.2. Interests and expectations for the system

In addition to needing to accommodate users that did not have previous computing experience another significant challenge within the organizational environment was that *the EMR system was expected to have a fairly large impact over a wide range of activities across the organization*. Actors with a variety of work roles had an interest in the system, and these actors conducted various activities at the hospital. These interests were often expressed in relation to their primary work activities [30] although secondary activities were also mentioned. The Hospital Chairman for example originally proposed the idea of adopting an EMR system in 2000. He is strategically interested in the hospital becoming a Hi-Tech Eye Research Centre and is confident that a medical information data-base related to the EMR system will be the best option to store, retrieve and analyze medical information for research purposes. He stated this by explaining,

Fig. 1. A photograph taken in a waiting room at SN. Urban areas of India tend to be crowded with people and the waiting room is no exception.

"We want to use the information and communication technology advances to the best advantage in this institution. EMR system will be very helpful to us for doing research either prospective or retrospective studies." (Manager_1 Dec. 2007)

The Medical Superintendant of the hospital also has a wide range of non clinical responsibilities and expressed interest in the system for quite a wide range of reasons. These interests included improved transparency and workflow, reducing waiting time for manual transport of paper records, and administrative support such as helping him find out how many surgeries have been performed each day, and how many patients were seen by each member of the health staff. He also expressed an interest in using the system to support the clinical staff in new ways, such as by including Decision Support Systems and helping practice Evidence Based Medicine. He explained,

"At present doctors may go by approximation or sometimes ask for help with colleagues for calculating dosage of the drug, all these calculations we would like to put in EMR." (Manager_2 Nov. 2007)

As expected the head of Medical Record Department (MRD) was enthusiastic the EMR system could help make his department more efficient. (Fig. 2) shows a picture taken of the paper archive room and illustrates the large number of paper records the department currently has to manage. He explained,

"Each year approximately 300,000 records are added to the archive, constantly we had to increase space for storing these records, but with creating electronic data-base, spatial and temporal problems is solved forever." (Manager_3 Dec. 2007)

In addition the MRD manager was also enthusiastic about using the system to support Telemedicine. This is because his department needs to handle information sent to and from archives outside the hospital, and from clinics in the surrounding area. He explained that,

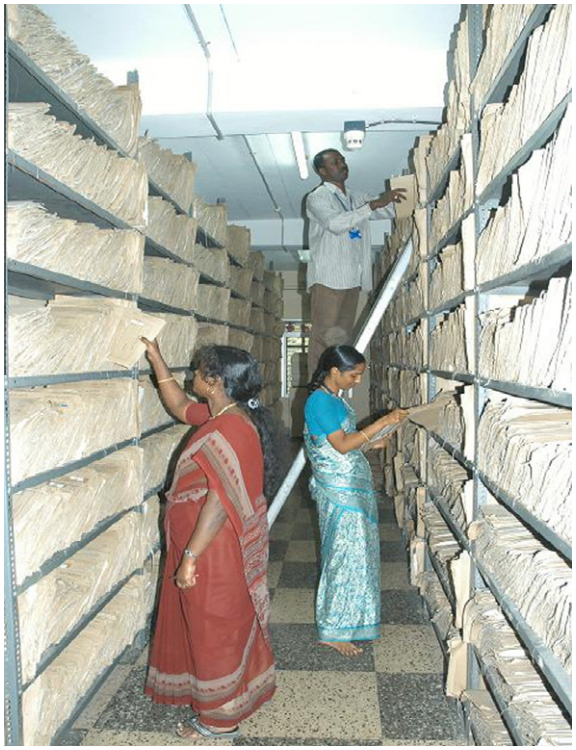

Fig. 2. The archive room at SN.

Fig. 3. A motor bike used for transporting paper records.

"In Chennai itself we have 5 clinics in different locations. The major problem is to transfer requested records from one location to another. Either manually or by transfer faxed copy or we have to scan and send in attached record and it takes lot of time and resources. With this EMR system record transfer is made easy and record loss is avoided." (Manager_3 Dec. 2007)

Today this transport of paper records from the hospital to clinics, and to and from the archives, is currently accomplished by using metal boxes that are fit on the back of a motor bike. Fig. 3 shows a picture of one of these motor bikes.

Not surprisingly the primary interest the clinical staff expressed for the EMR system was support for their clinical work. One optometrist for example commented about an interest in using the EMR system in order to view all past history for patients more easily than with paper records. He explained that with the current system this can be fairly difficult, as sometimes locating paper records can be a challenge. He explained,

"Sometimes patients visit without prior appointments even after few years of their last visit, then it takes 1 or 2 h to find that record. However with the EMR system this waiting time is saved, doesn't matter after how much period a patient is visiting."(Optometrist_1 Nov. 2007)

The consultants expressed an interest in the EMR system for a variety of reasons including being able to access patient medical information with just few clicks of a mouse. Some surgeons also mentioned an interest in accessing medical records from home in order to plan surgeries and see examination reports.

In addition to clinical benefits the consultants were also positive about non-clinical aspects of the system, such as its ability to support research. One of the consultants mentioned for example,

"I am interested because this EMR system is very good tool for accessing patients information in daily practice as well as the data stored will be a good resource to carry research." (Consultant_5 Dec. 2007)

4.2. Design history and strategy

Identifying the correct design method in this complex environment was a difficult task both for the hospital and later for an outside vendor that was hired to develop the system. At the time the study was conducted the iterative design and implementation of

the EMR system was still ongoing and had taken place over an 8 year period.

The initial plan for designing the system was to have the hospital IT staff develop the system without being given a concrete set of requirements and specifications. The end result was rejected by the health staff for various reasons. These included issues such as the user interface not containing all the required fields for data input. It also required a large amount of time for data entry due to a poorly designed user interface, and lead to disturbances in work flow.

When this system was rejected the Hospital Chairman arranged a meeting with the IT staff, Head of the MRD, and clinical staff in order to identify a more effective design process. A decision was made to send select members from each department to visit the UK and USA to survey hospitals that have adopted EMR systems so that they may learn from existing practice. The selected individuals observed the systems in use, enquired about how the systems were designed and implemented, and returned to SN with new ideas and strategies.

\A decision was then made to hire a private vendor to design the EMR system. The vendor is well known in the area and has been involved in developing EMR systems for the National Health Services in the UK. The vendor proceeded by using a design process that incorporated input from the Head Optometrist, the Medical Superintendent of the hospital and the Head of the MRD. Within a few months the vendor developed an EMR system based on these specifications with a user interface that "looked good on screen" (Manager_3 Dec. 2007). Attempts were made to implement this system into practice. Once again however the health staff rejected the design. The primary complaint was that the user interface was too inefficient. One of the managers at the hospital explained it like this,

> "At first the vendor created something that looked good on screen, but actually it was useless to doctors. If something needs 100 clicks before it can be filled in it is useless. Doctors' want fast and easy system." (Manager_3 Dec. 2007)

This failure made the vendor fairly discouraged and unsure if any system they developed at SN would be accepted by the health staff. They decided that if they were going to go forward that they would need to use an extensive version of PD that more directly involved a variety of staff from the hospital. Rather than just attempting to get clinical staff to provide input to an external design team, they requested for a consultant to step forward and actually lead the design team. A senior consultant, serving as a department head, (hereafter referred as Consultant_1) volunteered to assist in this regard. Consultant_1 noted that this was a fairly challenging process and explained that,

> "The main challenge in the development of the EMR was designing a user friendly screen for the data entry in the form of predetermined templates and to provide options to modify data if required." (Consultant_1 Nov. 2007).

Consultant_1 was not only involved in system design but also served as the "physician champion" of the system during the implementation process [14], [15]. In addition to Consultant_1 the vendor also hired a few senior members of the IT staff onto the development team. They had each worked at SN for 10 to 15 years and thus had a large knowledge base of the workflow and organizational issues at the hospital. They also had a strong relationship with members of the health staff and thus could help identify what problems they might face with the system, and also help identify what functionality they require. One of the former members of the IT staff for example was instructed to conduct observations in the offices of a few consultants and engage them in discussions about possible ways to assist their work with Information Systems.

Another aspect of the approach is that at some point some of the members of the IT staff hired by the vendor are expected to return to hospital as full time employees. During this period they will, among other things, continue to work on the EMR system by providing technical assistance, iterative improvements and help with upgrading the system. One of them explained his current situation like this,

> "I am working here from last 15 years, I am aware of workflow and many people from health staff are my good friends. (Consultant_1)'s contribution is enormous; he designs interfaces and explain how he wants the system to perform, and we make software based on his requirements. Though my employer has changed still I am working for this hospital." (Vendor Dec. 2007)

Consultant_1 was given a space in the development lab and initially worked 100% leading the user-interface design team for approximately 3 months until initial versions of all the user-interface modules had been completed. Afterwards Consultant_1 returned to treating patients during mornings, and has continued to work with the system during afternoons as needed. Input from other users was primarily gained from by Consultant_1 as needed based on his contacts in the hospital, and from people that volunteered to provide input on specific issues. Consultant_1 opportunistically arranged meetings with others outside the development lab in order to gain input from them without disrupting their time schedule. From time to time users would also arrange meetings with Consultant_1 and visit him in the development lab in order to provide input on issues they wanted addressed.

The design strategy ultimately proved successful and resulted in a design that was accepted by the clinical staff. All the modules of the EMR system were ready by end of 2006. A decision was then made to continue with iterative design after the system had been implemented. This would allow for changes to be made based on knowledge obtained during the actual use of the system. This process was still ongoing at the time of the study.

4.3. Critical technical system features

One of the primary reasons that the system was ultimately successfully adopted was the inclusion of a number of technical and social features of the system that intended to accommodate skeptical users and those lacking IT skills. The technical and social features were often interconnected in the sense that specific technical features were developed into the EMR system in order to support social changes. The critical technical and social system features are described in the next two sections.

As noted previously one of the most challenges technical features of the system to develop was an effective user interface. The strategy that Consultant_1 adopted in order to meet the needs of the users was to not only focus on making the system fast and easy to use, but also to make the interface as similar as possible to working with paper records. He explained,

> "I have tried to keep the interfaces as similar as paper records, so that users need not search for required fields to fill in. In addition, I have designed a template with relevant fields. For example if an optometrist clicks on fundus examination, only the field relevant to this examination is displayed they need just to fill the fields with the finding after examination" (Consultant_1 Dec. 2007).

The similarities between paper and electronic records can be seen in with the drawing tool shown in (Fig. 4) that was added to the system. The tool is based on electronic pen-pad technology

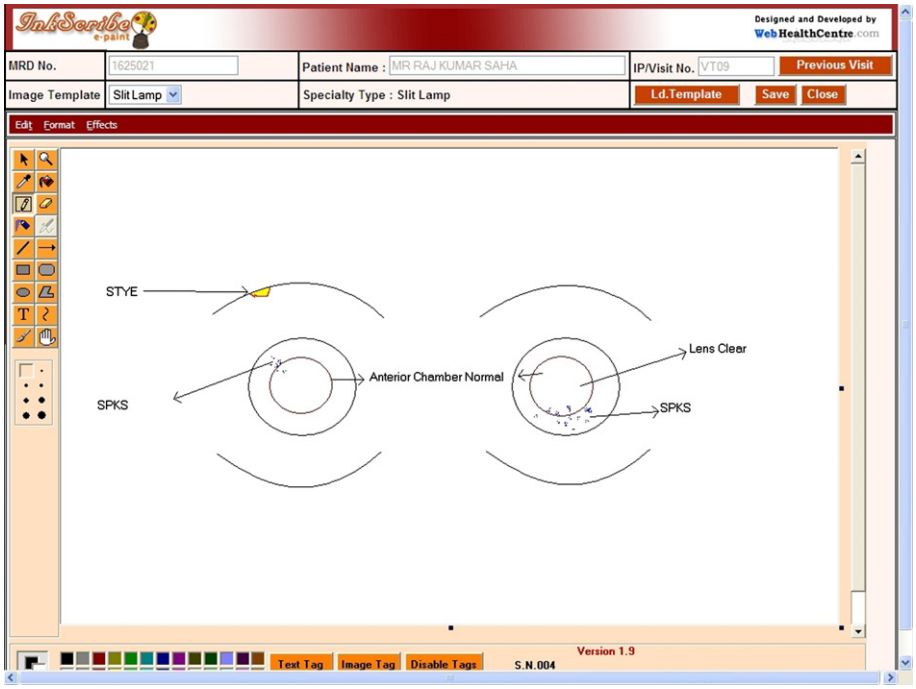

Fig. 4. A tool that allows consultants to input drawings using a pen interface in a similar manor to the way they work with paper records.

and allows a consultant to draw pictures in a similar way to they are used to drawing them with paper records. A picture of a paper record with such a drawing is shown in (Fig. 5).

An additional technical feature of the system that was useful for winning over users was an integrated paper backup system that allows the EMR system to be used in conjunction with the paper record system at the hospital. This not only made the system more reliable, but it also allowed the hospital to make use of the EMR system optional during clinical work. This enabled the hospital to use the stepwise implementation process that is described later.

4.4. Critical social system features

In addition to technical features, targeted social change was an important part of overall system. The implementation process was developed during meetings containing members from all the different departments after system development had finished at the end of 2006. The process included organizing training and awareness programs, and technical support for both health staff and administrative staff. Demo-CDs were distributed to users that allow them to practice using the system at home and, for example, learn the interface and templates used. Users were also given the option of practicing online via the hospital web page. The implementation process also considered the issue of some users being inexperienced using computers. One of the managers explained that,

> "First we selected a group of users who are fond of technology, and use computers more often. We trained them first. They learned the system very fast and were trainers for other people". (Manager_1 Nov. 2007.)

4.4.1. Stepwise Implementation

Another implementation tactic was the employment of a stepwise implementation process. The goal of this process was to slowly introduce the EMR system so that the clinical staff would have a considerable amount of time to get used to the system before using it during all clinical work.

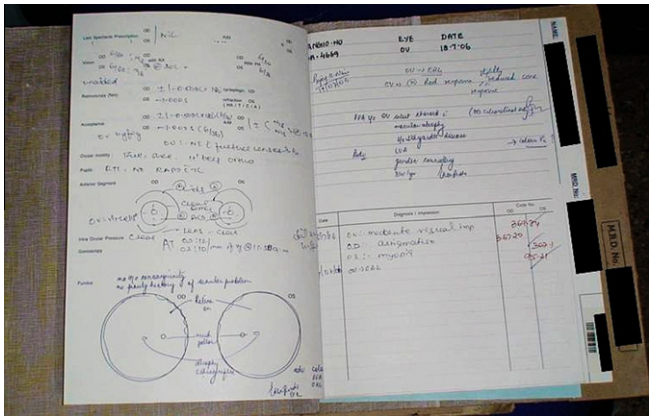

Fig. 5. A paper record at SN with a drawing that is similar to those created with the drawing tool in the EMR system.

The stepwise implementation process involved the system first being used at the evening outpatient clinic, and only for patients visiting the hospital for the first time. An electronic record was created for each of these new patients and existing patients were continued to be serviced with their existing paper record. A limit was also imposed so that members of the health staff used the EMR system for a limited number of patients each day, and treated the rest of their patients while using paper records. The number of patients they serviced while using the EMR system was slowly increased until all the new patients visiting the evening clinic were consulted with an electronic record. The same strategy was then applied for patients visiting the day clinic. At the time of the study some of the new patients at the day clinic were still having a paper record created for them. Since that time the day clinic has also completed this process. The system is thus fully implemented at this time as all new patients visiting the hospital have an electronic record created for them.

4.4.2. Optional usage of the EMR with incentives for use

In addition to supporting a stepwise implementation process the paper backup system also allowed SN to make the use of

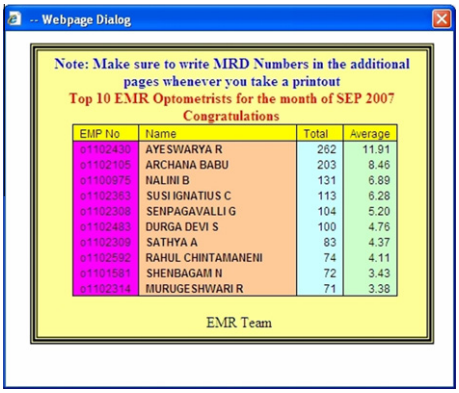

Fig. 6. A screen shot showing a list of the top 10 most active EMR users among optometrists.

electronic records during clinical consultation completely optional for the health staff. They could choose to use the system, or if they felt uncomfortable with it, they can work with a paper print out of the electronic record of a patient.

Since the use of the system is optional, the management created economic and social incentives in order to encourage the adoption of the system by the clinical staff. Before the EMR system was in use the optometrists received a financial bonus for every patient they checked after the 12th patient each day. After implementing the EMR system however, the management decided to give this bonus only for extra patients checked while using the EMR system.

Social incentives were also created by developing a 'Top 10 list' of health staff that shows the most frequent users for each month. The 'Top 10 list' is shown in (Fig. 6) and is displayed to each user every time they log onto the system. It is interesting to note that the "Top 10 List" is an illustrative example of a technical feature in the system that was developed for the sole purpose of creating change by altering social attitudes towards the technology.

4.4.3. Making computing more natural for users

Another way in which management attempted to change attitudes towards the system was to help users feel more comfortable with computing in general by supporting their use of computers in other contexts. Computers were installed in reading rooms and resting rooms for the heath staff that they can use for general purposes, such as sending email and surfing the Internet. Another tactic employed was to provide assistance to users that choose to have a computer at home. The IT manager of the hospital explained,

> "We are trying our best, helping health staff at personal level. Hospital management has decided that if any health staff wants to purchase computer, one of our staff will do counseling and help in installation and provide technical assistance. " (Manager_4 Dec 2007).

5. Discussion

One of the significant findings of the study was that, similar to large hospital environments in developed countries, the design environment at SN proved to be quite complex. A number of challenges were in place that easily could have derailed the system from ever being successfully adopted. Early versions of the system did in fact fail due to user resistance. Despite these challenges however a version of the EMR system that was acceptable to the health staff was eventually adopted into clinical practice.

A significant factor related to the complex organizational environment at SN was that the EMR system was expected to deliver a wide range of benefits. Many of these benefits such as improved support for Telemedicine and reduction in storage space and waiting times have not been previously reported as reasons to adopt EMR systems in developing countries [1]. Support for Telemedicine adds additional technical and social requirements on a system with issues such as data security, effects on work flow, and incentive structures becoming more complicated. The reduction in storage space and waiting times also seems to be a highly relevant issue for urban hospitals in developing countries. Storage of records may be problematic due to a high density of patients. Poor ICT infrastructure and a lack of cultural norms using technology may make the practice of creating prior appointments more difficult for patients. The potential benefits for EMR systems may thus be even broader in the context of developing countries than has been reported for developed countries, in the sense that they can help to meet similar needs related to supporting clinical work and research, and also can be used to help mitigate some specific local challenges related to overpopulation and lack of resources and infrastructure.

The broad potential benefits for these systems also present additional challenges as they will present additional technical and social system requirements. This can be considered in light of existing studies of EMR systems in developing countries, that have not been conducted at large hospitals, and have generally not reported on issues related to organizational complexity like studies from developed countries [1]. This leaves an unclear picture regarding the complexity that may be encountered when designing EMR systems for large hospitals in the developing world. This study suggests that in many contexts complex environments similar to that encountered in developed countries can be encountered in developing countries. Understanding of socio-organizational issues, rather than only developed versus developing world specific issues, will often be critical to the successful adoption of EMR systems. Robust design and implementation practices will need to be employed, and further studies to improve understanding of the environment at specific hospitals contexts in developing countries related to the adoption of EMR systems should prove valuable.

5.1. EMR design strategies

Although many details of the design method used at SN were not uncovered during the study, the information that was available from the data, points to a number of issues that can be used to aid in the design of EMR systems. This includes issues related to design strategy, and social and technical features of the systems.

5.1.1. Handling differing expectations from the system by different actors

One perspective on the wide range of expectations and interests in the EMR system at SN is that they may be considered in the context of the actors primary work activities [30]. This is somewhat related to the Task-technology fit concept in that end user tasks should match functionality [31]. The communication style and mind state of stakeholders has different implications however, as it helps to provide understanding of how different stakeholders may view the system before and after it has been developed, and also how to approach communication with these stakeholders. It may also be useful for understanding potential political and organizational conflicts that may need to be considered throughout the process of designing and implementing the system, and that may need to be eventually reflected in the features of the system itself.

A number of the expected benefits for the system were related to supporting clinical work, such as easier access to patient records, the use of decision support systems and support for evidence based medicine, Many of the expected benefits reported by non-clinical staff however involve secondary usage of EMR data outside the

context of which the data is produced (the clinical context), such as to support research and administrative tasks. The management at SN for example was interested in a wide variety of non clinical uses of the system including support for administrative work. The majority of work inputting data into the system however is done by health staff in the clinical context. A potential disparity in benefits and work thus exists. Early versions of the EMR system were not created with extensive input from the clinical staff and were indeed rejected by them because of usability problems in the clinical context. The failure to gain the necessary input from the clinical staff on these versions of the system can be explained by the issues mentioned above. Discussions with managers may not have made it obvious to the design teams about how critically necessary it would be to engage the clinical staff for input. Additionally, approaching the staff for input would not have been intuitive for them, since it would not be a usual part of organizational change processes.

Although they do create additional challenges, the wide interests in the system may also provide an advantage however since it has been noted that the more collective benefits that a system is expected to bring, that the more the management will be committed to ensuring its success [23]. At SN there were indications of this since the hospital management was dedicated to the success of the system to such a large extent that they were willing to accept an open ended process of iterative design over several years that included two rounds of complete failure.

When considered together these issues may be of interest when approaching design for the organization as a whole, and also when communicating design strategies and processes to hospital management and other stakeholders that may affect EMR adoption. This knowledge may be applied for example in order to *gain support for iterative participatory design by communicating the following*:

- Emphasize the broad collective benefits of the system (as suggested in [23]).
- Clarify benefits to the respective managers' primary work activities.
- Stress the critical issue of effective design for the clinical context and need for extensive user input over a long period of time both before and after implementation.

5.1.2. System features to support challenging users

In addition to the complex setting at SN other factors related to the work staff complicated the adoption of the system. Users had rejected previous versions of the system and many of them lacked IT skills. These are highly relevant issues when designing EMR systems in both developing and developed countries. Studies of EMR systems in the developed world have noted a lack of computing skills as a specific issue which can lead to system failure [15]. The high failure rate of MI systems due to user and staff resistance [8] also suggests that projects will often be conducted in a context where users have previously rejected systems. The success at SN in dealing with such a user group gives a concrete example of how in some contexts it is possible to overcome these challenges. Some specific (technical and social) features of the EMR system design at SN can serve as starting points when considering how to meet organizational and user needs in similar environments (including skeptical users and those lacking IT skills) in both developing and developed countries. These include:

- Investigate user interfaces based on efficient templates for data entry that are as similar as possible to paper records. While this may not be the preferred method in some contexts, it may help reduce resistance in difficult environments by making the system easier to learn, and by making the transition from paper to electronic records more natural for users. It may also be a method to help guide the work of a physician champion serving as the leader of the UI design team (as was the case at SN). Clinical staff often struggle, and can overcomplicate matters, when given too much control over UI design [20]. Having a target that is concrete and straightforward can help avoid this problem and may help to increase the success rate of their work.
- Consider optional rather than mandatory use of the system while creating incentives for users to adopt it. This method may be particularly useful in contexts with high potential risk for failure, yet with high potential for reward for successful implementation. This approach may also put technical requirements on the system, such as requiring a fully functional paper backup system to be included. The specific incentives that will be appropriate are likely to be highly situational and will need to be tailored to each individual context.
- Users that lack computing experience may be helped by programs that promote computing outside the EMR context.
- The implementation process may benefit by creating a "snowball effect" where technology savvy users are first trained with the system, and then used in order to assist in training other users.

5.1.3. Participatory design and implementation

The process for design and implementation of the system may also be worth considering when approaching the development of EMR systems in similar settings. It is widely accepted that user input is valuable during the design process. The best method(s) for obtaining user input is still a fairly open question however. In addition to challenges related to comparing studies done in different cultural contexts, another challenge is that formal experiments comparing different methods for gaining user input are very difficult to perform in a real workplace context [19]. This study is thus notable in that it reports on failed and successful design processes at the same hospital, and also in that the data was collected, and is being reported by, outsiders not involved in the design process.

The second version of the EMR system was designed by an experienced consultancy firm that gained input from key personnel at SN. The design team still did not manage to create an acceptable design with this process however. Considering the hierarchical nature of SN, and lack of existing structures such as labor unions that could be used for interacting with different user groups, it is not surprising that the initial participatory design strategy did not directly involve users of the system beyond the management level. User input from a few managers during the initial phase of software development deemed to be inadequate however.

The process that eventually lead to an acceptable design at SN used an extensive version of participatory design and implementation, that included the use of cooperative and evolutionary prototyping [32,33] and that continued with iterative improvements after the system had been implemented. Users were also more extensively involved in the process than by only providing design input to external consultants. Staff from the hospital lead the UI design team, created and communicated their designs directly to the software development team, and performed software development. An integrated approach was also used between design and implementation with many of the same staff being involved in both phases. The concept of a "physician champion" has been reported as key to successful implementation of EMR systems [14,15]. In this case *the physician champion also led the UI design team*. This strategy may prove effective for a variety of reasons including that the contacts and knowledge the person has throughout the hospital can be used to help organize user input when there is a lack of unions or other organizations to help recruit users.

Some of the IT staff that was hired by the vendor to conduct software development will also return to the hospital in the future

to help with support, maintenance and iterative improvements of the system independently from the vendor. This process reflects the current discussion critiquing PD conducted by external designers as often failing to provide the necessary level of user input over time [34]. The experience at SN gives a concrete example of how to start building teams that allow in depth knowledge obtained during the design, development and implementation of an EMR system to be contained within a hospital. This may thus used as a starting point in considering how to "design a [socio-technical] system that more or less then designs itself" ([34], p. S103) The long term success of the strategy in allowing SN to continue with iterative improvements of the system independently from the vendor is still unclear however, and is something worthy of investigation in the future.

5.2. Limitations

As with all case studies the usual limitations must be noted with respect to problems that may arise when trying to generalize the results in dissimilar settings [35]. In India for example many health workers at public hospitals are members of labor unions. In that situation the relationship between management, EMR design teams, and health care workers may be fundamentally different than reported in this study. The limitations with data analysis noted in the methods section are also worth re-stating, as the somewhat limited scope of the study during the data collection phase, and problems in conducting further data analysis due to partial data loss, may have resulted in a number of interesting and important issues related to the findings not being reported in the study.

6. Conclusions

A wide range of factors can affect the adoption of EMR systems at large hospitals in developing countries. A wide range of potential benefits can be attributed to these systems, and some of these benefits, such as reducing waiting times for patients, may in fact be greater for hospitals in the developing world than in the developed world. Similar to the developed world the environment at large hospitals in developing countries can be quite complex. Challenges related to meeting varying interests in the system from different actors, and in accommodating skeptical users and those that lack IT skills will be encountered in many situations.

These challenges are possible to overcome however through the use of effective communication practices with managers in order to win support for the use of PD methods, and the extensive use of these methods. High levels of user input from the clinical staff will be needed and can be aided by the use of techniques such as cooperative and evolutionary prototyping, as well as an integrated approach to design and implementation that includes using the physician champion as the lead UI designer.

The eventual system that is implemented may need to include features that pay special attention to accommodating skeptical users and those lacking IT skills. Consider pursuing user interfaces that are very similar to paper records in order to help users feel more comfortable with adopting the system. Social elements of the system that include social and financial incentives to use the system, as well as programs that help promote computing outside the work context, may also prove valuable.

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