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Human Computer Interaction Issues in Eliciting User Requirements for an Electronic Patient Record with Multiple Users

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Abstract

Emphasis on usability for all users at the design stage of an Electronic Patient Record (EPR) is directly relative to successful implementation. This article outlines the values of considering the heterogeneity of users in EPR systems. We review the literature available on the design of EPR systems with a focus on its usability principles. A case study of how an outpatient EPR system was successfully implemented in the Epilepsy Unit of Beaumont Hospital, Dublin, with due importance to usability testing for a multidisciplinary team is explored.

1. Introduction

The delivery of high quality, patient centred healthcare relies on the collaborative efforts of a multidisciplinary team. This can include but is not limited to for example, doctors, nurses, social workers, occupational health specialists, radiologists, laboratory scientists, pharmacists and administrative staff. In a paper based healthcare environment, each discipline utilises the section of the medical record which is relevant to that discipline and is free to view other sections as appropriate or required. In an electronic patient record (EPR), it is important that the relevant information for each discipline is as readily available to each user as it is with the paper-based system. In order for this to be the case, the EPR must be designed with consideration of all possible user groups. This may involve the design of multiple user interfaces to accommodate each type of professional and role requirements.

The purpose of this report is to highlight the heterogeneity of roles using an EPR system and to ascertain whether consideration of all user requirements at the design stage is directly relative to the success of the EPR system in terms

of efficiencies gained and benefits realised following implementation. This will be demonstrated by a review of how the designers of a successfully implemented EPR system in the epilepsy unit of Beaumont Hospital dealt with usability testing for the multidisciplinary team collaborating in the unit with a focus on usability. We compliment the case report by a review of related work available on the design of EPR systems. We conclude with a discussion on the relationship of usability testing for multiple users of an EPR system to the success of the EPR system following implementation in terms of benefits realisation.

2. Overview

A literature Review was conducted to explore how design, usability and Human Computer Interaction (HCI) issues were addressed in the process and methodology used in elucidating the user requirements in an EPR. Several have investigated user needs and how they should be considered in the design of an EPR, where there are multiple users who work collaboratively [2, 6, 11]. Users will seek role based tools, relevant to their role and function that are available at the point of care and use [11], which suggests that the process of elucidating user requirements is a critical factor in how users will interact with a system. It is also crucial in a multidisciplinary EPR that users will have all relevant and useful data available to them at time of need. Where the objective is to support communication and collaborative work between multiple users taking into account that a particular person may play different roles on different teams, it is necessary to allow for in the design process that team members, teams and roles may evolve and indeed change with time [15]. So, data modelling undertaken prior to the design of the epilepsy EPR will be of benefit to users in their individual roles and also the workshops, prototyping and reporting methodologies used will facilitate collaborative working.

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2.1. EPR systems with a focus on usability

In order to successfully implement an EPR, it is imperative that users are incorporated into the design phase. The design to reality gap needs to be closed in order for successful EPR implementation, which involves altering the design of the system so it is as close to reality as possible, while altering the current reality so that it is similar to the design. Prototyping is proven to be a useful tool in the design phase so that the users have a feel for the design before implementation. The prototyping process allows the users to better understand what changes the system will bring to their current work systems. Prototyping is also a mechanism that legitimises the process of improvisation. It helps close the design - reality gap within EHR development, and it is associated with successful implementations [3]. It is important that end users are aware of the benefits of the new system at the early stage of the project. Such benefits may include reduced work pressure or perceived ineffectiveness or old systems [3]. The end users of the system should contribute to and be considered during the design, development and implementation phases [18].

Physicians are the most likely group to resist change [6]. This may be a result of many systems being developed for physicians which have made their job more difficult rather than more efficient. A system should enhance the workflow for the end-users by providing additional support rather than creating unnecessary work for physicians [2]. Computer systems have been known to disrupt the physicians time with the patient. Leonard says that during the design phase, end users should be asked what they would need from the system rather than asking them to review the system options and select their preference, as physicians are not always technology savvy [6]. Software developers and users need to discuss and agree on the possible solutions of the system prior to implementation. Acting out typical work processes makes it easier to identify which features are needed for a new system [13].

Human computer interaction is a complex interaction between theory and application involving humans, machines, tasks and the environment [8]. Designing a successful user interface in an EPR is one of the most important challenges in the field of health informatics. Current health information systems do not sufficiently address usability, and many information systems are lacking in providing access to information when it is required [15]. A poor arrangement of the information on a screen has been shown to delay clinicians in delivering timely clinical decisions [14]. Implementation of terms by developers with which clinicians are unfamiliar can also result in a poorly designed system.

EPRs can fail if simple routine tasks such as entering an order or looking up a lab result involve a large number of mouse clicks. We are warned that EPRs without certain

standards of stability, interoperability, security and privacy are less durable [12]. It is argued that even though more attention is now given to developing standards for EPR implementation, less effort is devoted to the designing of visualisation and navigation techniques within the EPRs [9]. Poorly presented patient data can lead to poorly informed clinicians, higher risk of medications errors, unnecessary investigations and referrals [17]. Indeed applications have been reported that seem to foster errors rather than reduce the likelihood of errors [1].

A poor understanding of the issues related to the cognitive process involved in HCI can also lead to less user friendly design interfaces. Failure in achieving semantic interoperability can lead to double data entry, poor integration of local workflows and failure to meet user requirements [5]. A focus on the design of user interfaces that is based on user needs can contribute to an ever increasing number of computer users, characterised by diverse abilities, requirements and preferences [4]. The HCI process here can be very complex and knowledge demanding. In addition, users working with various levels of experience need to find the right balance in interacting with the system. If HCI designs demand of the user to perform more steps to complete a task then it is likely to create mental fatigue and increase the possibility of human error. Conflict between user expectations and what the designer develops is one of the most commonly seen problems in EPR implementation. A case study on better iconographic design in EPRs user interfaces, attributes the failures of EPRs to i) underrating the usability principles and human factors, ii) handling the projects solely as IT projects, iii) not taking into consideration the cognitive requirements of the user, iv) failure in collecting interface requirements of the user, v) failure in observing the practices of the user in the working environment and vi) failure in not implementing representational analysis [16].

McQuaid et al. explain that reasons for low use of EPRs are multifaceted and determined by user training, user friendliness of the information system, ergonomics of the environment and existing workflow patterns [10]. The problems with data input as one of the major barriers to EPR systems was considered in [7] and it was found that entering structured data requires more user time than entry of free-text information, as the user has to correlate their concepts into the computers concepts, and spend time searching for the right computer code. Generally, there is a broad consensus that response time is extremely important in any successful EPR system, and real world systems do not seem to have solved this problem. Lack of common ground between the users thought processes and the knowledge architecture on which the HCI is built can be counterproductive and data entry into these EPR systems can be time consuming. Poor analysis of the benefits and stresses from the perspective of the users and not comparing the perceived changes by in-

dividual professional users with the effects on other professional user groups can be the determinants in the successful implementation of HCI values in EPRs.

3. Case Study

The epilepsy programme at Beaumont hospital is the main tertiary referral centre for patients with epilepsy and related disorders in Beaumont. It integrates clinical care and research through the work of a multidisciplinary team who provide services such as; an epilepsy out-patient department (OPD), a nurse specialist telephone advice service, the epilepsy pregnancy register, community services and a long term monitoring unit. The aim of the epilepsy programme is to continuously manage the care of patients with epilepsy and their carers. The diagnosis and treatment of epilepsy depend on accurate integration and correlation of clinical data from multiple heterogeneous sources. A secure, standardised EPR can help to overcome data management limitations by allowing multiple users simultaneous access to information at different locations, where and when it is needed. It can facilitate ease of updating, interrogation, auditing and detailed analysis of complex data. The programme's principal aim in terms of Information and Communication Technology (ICT) is to develop and implement an integrated and secure epilepsy EPR to support the management and development of epilepsy clinical and research services.

The epilepsy EPR is currently used routinely in a live clinical setting by a multidisciplinary team of healthcare professionals at the point of care e.g. the epilepsy OPD. It was designed, developed and implemented incrementally over a four year period to include clinic administration, demographics, social history, epilepsy history, anti epileptic drugs (AED), allergies, OPD plan and clinical investigations modules with enhancements. New modules are currently in development. Access to the epilepsy EPR is available to authorised and authenticated users from any location within the hospital. It is a bespoke system with specific interfaces to internal hospital systems such as the administration hospital information system (HIS), investigations (pathology results) from the Laboratory Information System (LIS) and the OPD ordering system.

3.1. Methodology

A socio technical approach was used in the design of the epilepsy EPR. This approach considers the interrelatedness of human, organisational and technical components when designing an ICT system. Iterative development was used in each phase of the EPR project lifecycle from system design, development, testing (system and user acceptance), and implementation to evaluation. It is important to note that all

information used in this report regarding the epilepsy EPR was gathered from published literature available in the public domain. The design approach discussed below reflects a particular point in time early in the planning of the design of the epilepsy EPR. A collaborative effort between the EPR end users, business analyst and software developers greatly helped to produce an end-product that more closely meets the users' needs.

3.2. Design approach taken to elicit user requirements

The design of the EPR involved conducting business process modelling (BPM) and the elicitation and modelling of user requirements. BPM specifically focused on the patients journey through the OPD and the work activities of clinical users. This was conducted using ethnographic analysis e.g. observation of clinicians working in their own environment. Process maps were drawn up and confirmed with end users. The determination of functional and non-functional user requirements was realised through a series of traditional requirements elicitation techniques such as requirements engineering workshops and multi-stage Delphi interviews. Initial prototypes of the system (included UI and system functionality) were developed based on the user requirements which were reviewed and verified at joint application design sessions attended by IT developers and champion user representatives. System design and user requirements evolved and new prototypes were developed on paper and on mock-up screens. Any changes required were written into the user requirements. Iterative prototyping was key to the design approach and involved regular user feedback, mainly concentrating on changing the system functionality and requirements.

Development involved software design, engineering and testing which was carried out by the software development team. Continuous communication between the projects business analyst and software developers informed system refinement to optimally meet user requirements prior to end-user training and implementation. This iterative approach aimed to deliver prototypes of the system solution to users in shorter development lifecycles, enhancing closer user participation and earlier retrieval of user feedback. This approach resulted in better adaptation to business and user requirements and enhanced user acceptance testing.

3.3. Strengths of the design approach

Data modelling involved the collection of required data fields and clinical information required for the EPR over an eight month period which was put into a composite document agreed with the users. This gave users a feeling of greater ownership of the project. It is critical that the users'

opinions are incorporated into the project in order to have a successful implementation.

The ethnographic analysis was carried out during the design phase. During this analysis the staff working in OPD was observed as they carried out their daily activities. In particular, the various communications between the staff and the patients were recorded. Other data recorded included information on location of staff, data sources used for patient information, types of patient encounters (e.g. new patient vs. review patient), patient waiting times, types of information recorded and time spent by users in querying and updating charts. Following on from the ethnographic analysis a workflow process was constructed to optimise time management of users. This proved a useful tool in facilitating work practice changes, which can be a significant constraint in the introduction and implementation of a new IT system. Process maps were produced from this analysis, which helped to identify points at which decisions are made. The process maps encouraged user involvement as they could identify any changes required in the process maps. When the users are involved in the design phase, they are more likely to want to use the system.

Interviews and workshops were held with users and the requirement developers. Users were asked both open and closed questions and were encouraged to provide detail around their functional requirements. Interviews and workshops allow requirement developers to fully understand all the roles and needs of the various system users. Workshops encouraged discussion of ideas and allowed the stakeholders to be introduced, thus developing relationships.

Once use cases had been established, prototyping was conducted during the design phase. Presentation slides were used to illustrate to users how the system would work through screenshots. Feedback from users helped to adapt the use cases to the users' requirements facilitating an iterative development process. Thus changes were made to the system before it was fully implemented. The users could relate better to the images compared with a list of functionalities. The screenshots allowed the users to state where they would make changes to the system. Making changes at this stage reduces the amount of alterations required after implementation. UML modelling allowed for visual representation of use cases and their sequence to users as opposed to complex text descriptions.

Each user identified the various reports they needed to be generated by the system. Users were asked to document how often they required each of the reports, for example daily, weekly, monthly, or annual. By documenting a list of reports, the software designers were able to identify unnecessary duplicate reports and they were also able to organise the reports into separate categories.

All of these techniques carried out during the design phase fully incorporated the potential users and provided

the software developers with the necessary requirements to implement the system. This inevitably reduces the amount of changes required to the system post implementation and will influence user adoption of the system.

The use of various techniques in elucidating the user requirements was very time consuming for both the project team and the users. In a busy healthcare environment it can be difficult to prove the benefits of applying significant groundwork prior to implementation. This is one of the challenges faced by a bottom up approach. Also, the change in work practices was a significant constraint, which was successfully overcome through more direct user involvement in the design process. The use of screenshots as a means of prototyping received good feedback from all users. Comments and feedback indicated that the EPR facilitates collaborative working and good communication between various user roles.

3.4. Lessons Learned

This observational field study of the epilepsy EPR reveals a lengthy transition phase required, and various HCI issues to be addressed, in the implementation of a flawless EPR [10]. The epilepsy EPR was used in parallel to the paper based patient record, which can result in inconsistencies in making clinical decisions. The response time of the EPR has been reported to be slow from time to time. The conflict in the use of generic or trade names for prescribing drugs by the clinicians via the EPR was also raised as an issue. Contents arrangement in updating patient data by the user was not always user friendly. Even though the AED (Anti-epileptic drug) module structure in the EPR prompts to ask patients clinically relevant questions, the feasibility of this feature in a busy OPD can be time consuming resulting in mental fatigue for the users. Flow of functionality issues such as a user having to use too many clicks (actions) was also noted. For example, a nurse will have several clicks to note the reason for a drug discontinuation. The EPR fails to address the non-epileptic drug prescriptions, which may be required for epileptic patients with other diseases. Commonly seen HCI issues like colour scheme and labels on the display were raised. Clinicians who were inactive for a short period of time, for example while examining a patient, were logged out for security reasons and had to log in repeatedly. Poor presentation of the medications use interface screen was also reported. Users found the information screen too long and wide and required a lot of scrolling both up and down, which they disliked. The six-month clinical rotation system for the clinicians followed in the Irish health care system can demand a regular training schedule for the new incoming clinicians in the use of the EPR. Thus, despite the process of data modelling, prototyping, workshops in meeting the user requirements, the users deviated from

the recommended mode of usage. McQuaid et al. clarify that this deviation may likely have been influenced by the change in workflow practice and its negative effect on meeting targets [10].

4. Conclusion and Future Work

This review has demonstrated that the information contained within an EPR is accessed by a multidisciplinary team of users, each requiring access and edit rights to different aspects of the record. It appears that the HCI solution for this heterogeneity is to implement role based access controls such that users can only see the information that is relevant to the aspect of patient care for which they are responsible. This has the added advantage of improving information security and privacy and confidentiality by ensuring access to sensitive personal health information is more tightly controlled. It is also evident that as much attention to usability and HCI at the early design phase of the EPR system is essential in order to increase the users uptake, buy-in and usage of the system. The use of ethnographic analysis to fully understand the roles and requirements of all staff has proven very useful in the development of the epilepsy EPR system. At an individual staff member level, data modelling appears beneficial whereas iterative prototyping aids the developer in understanding the collaborative approach taken to patient care by multidisciplinary teams. It has also been shown that employing different methods of discovery to fully ascertain all users requirements such as those mentioned above is most beneficial to ensuring strong usability of a system rather than just one method. Involvement of the key stakeholders in these ways also increases the likelihood that a system will be used. On the other hand, it appears there is room for further research into usability of new systems as there is a significant transition period from paper based to electronic records where both systems must be employed. This period of change can severely reduce efficiency and patient safety as users deal with increased workloads. The knock on effect of this transition period can result in a reversal of appetite among users to employ the new system, effectively halting progress. It is crucial to the success of the EPR that this period is managed carefully and where possible, the extra workload placed on users reduced. Overall, it is clear that the greater time invested in the early stages of system development on HCI issues and the diverse needs of different users, the more likely a system is to undergo a successful implementation with the minimum disruption to services.

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