ePOC: Mobile Clinical Information Access and Diffusion in Ambulatory Care Service Settings

Peter Eklund
School of Economics and Information Systems
University of Wollongong
NSW, 2522, AUSTRALIA
peklund@uow.edu.au

Jason Sargent
School of Economics and Information Systems
University of Wollongong
NSW, 2522, AUSTRALIA
jsargent@uow.edu.au

Abstract *This paper represents a preliminary overview (work-in-progress) of a mobile e-Health research and development project and the intrinsic considerations which arise when designing such patient data management systems tailored to ambulatory care. Its purpose is to give an outline of the issues that allow technological enablement of electronic patient data management in the delivery of home-based medical care. While the replacement of more traditional paper-based patient data management using Personal Digital Assistants as a collection platform is technically straightforward, the organizational realignment of an electronic document management system requires careful study and deployment in order to maximize success. We outline the methodological considerations for document management diffusion within this e-Health setting and describe the issues, architecture and proposed rollout of an electronic Point-Of-Care (ePOC) system.*

Keywords e-Health, document management and workflow, information access and diffusion

1. Introduction

Hospital in the Home (HITH) patients are those who without the provision of the hospital in the home service would require inpatient care by the nature of their medical or social condition [5]. Traditional community-based healthcare services such as HITH and Ambulatory Care are based on a healthcare delivery model of providing episodes of care to decentralised hospital outpatients; in the patient's own home or aged-care facility. However, the information management model utilised by HITH and Ambulatory Care service providers such as The Ambulatory Care Team (TACT) Northern Illawarra is centralised. A patient's electronic medical record (EMR) is only accessible by a TACT clinician while the clinician is located within the wired hospital network architecture, yet the treatment of the patient (based on reference to the EMR) occurs away from such wired architecture. This misalignment of models is at best problematic by creating inefficiencies and duplication in regards to clinical information access and diffusion.

A hybrid information system of paper and electronic formats exists for Ambulatory Care. After referral of a patient, the system process begins with downloading the patient's EMR (a task performed by TACT administration personnel). The EMR is printed and appended to an assortment of paper-based forms that are utilised during the patient visit for data collection pertaining to the patient's episode of care (treatment). Finally, upon return to the office, post-visit clinician documentation is forwarded to a data entry clerk for transcription and the process of electronic upload of the updated patient record to an appropriate centralised patient/ hospital database occurs. A complete paper record however, is also stored on-site at the TACT office. This document workflow therefore corresponds to a paper-based model of information management that lends itself to a more integrated electronic document management system.

In a hybrid system of this sort, alignment is needed between the models of *service* and *information management* for mobile community-based healthcare to occur "...[for] ICT to improve the delivery of healthcare and drive efficiencies through the health sector" [3]. As early as 2001, the New South Wales Department of Health recognised effective healthcare delivery within community-based health services depends on efficient information access. [15]. More recently, the Australian Government flagged e-Health as a

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priority area, noting that ICT will be integral to the strategy of reforming and improving delivery of healthcare in Australia [3]. Leveraging the utility of mobile devices such as Personal Digital Assistants (PDAs) in addressing these needs requires several alignments for a project such as this to succeed: (i) alignment between the legacy document management and new technology, (ii) organisational realignment of the technology to institutional and legal collection requirements (iii) sensitivity of the electronic document collection and its operators, in this case Health care workers.

2. Legacy Document Management

A systematic approach must be taken to transforming paper-based systems to electronic systems. In the context of Ambulatory Care, this systematic approach includes setting a baseline for capturing clinical data requirements by adhering to minimum data sets. Further, noting points of data collection and diffusion along clinical pathways helps to identify feeder systems (many of which are legacy systems).

Minimum Data Sets

An important consideration in designing mobile-based information systems for Ambulatory Care is the capture of appropriate, and necessary, data. Information systems (both electronic and paper-based) for Ambulatory Care are built around minimum data sets. Prior to the development of the Victorian HITH Minimum Data Set, data sets focused upon either inpatient areas or community-based care. Therefore, the individual data sets did not meet the requirements of HITH programs, as these programs cross care boundaries from the acute inpatient setting to the community [1].

Feeder System Integration

Integration of any proposed electronic system will centre on linking of records to clinical guidelines and protocols if "best-practice is to be embedded as an integral part of the health care delivery process" [6]. Alignment between legacy document management and new technologies is best achieved through an investigation of feeder systems on which any new technology device (PDA) will rely upon to populate fields in a patient's consolidated health record. Investigations have been carried out to determine what databases and which NSW Health information systems contain the data required to provide the PDA with necessary patient and clinical record information. In addition, links between NSW and regional health information systems have been studied. The outcome of this analysis shows that the Community Health Information Management Enterprise (CHIME) system holds the registration details for TACT clients and is the main information patient demographic system that TACT interacts with.

Other related patient data is also accessed from other information sources, including medications, pathology and radiology results held in other health information systems within the regional and state-based health system. However, both the present and future CHIME-based data collection is intended to remain paper-based for the ambulatory care health workers in the foreseeable future. Therefore, a PDA-based collection system has natural advantages to the existing health delivery and information acquisition regimes.

The PDA-based clinical recording system for ambulatory health workers confronts its main difficulty in terms of its integration with existing NSW Health and regional information systems and their data. Therefore the problems for developing electronic Point-Of-Care systems are twofold (i) to obtain the authority to access appropriate information and (ii) to electronically return the information collected from the mobile system to the feeder health information systems. In both instances, the person(s) performing data collection and dissemination roles in the TACT process will not change when TACT paper-based systems transition to an electronic Point-Of-Care (ePOC) system. The only differentiation will be in the data format; digitized compared to hand written or typed. This is anticipated to alleviate any 'authority to access' issues.

Messaging

Connection of distributed e-Health systems requires support by generic middleware components, while interoperability is addressed by messaging. A Health Level 7 (HL7) messaging gateway handles messaging from a clinical trial server to the PDA. HL7 is an ANSI-accredited standards developing organization "dedicated to providing a comprehensive framework and related standards for the exchange, integration, sharing, and retrieval of electronic health information that supports clinical practice and the management, delivery and evaluation of health services" [8]. HL7 Version 3 will be a key part of the contribution of IT to healthcare's reaching new levels of (1) effective and cost-efficient patient care decisions, (2) safety and cost savings that come from 'doing it right,' in the sense of preventing avoidable errors, and (3) the aggregation of health information for evidence-based medicine and databased policy [19].

Once appropriate applications are implemented for TACT, (such as CHIME appointments and similar) messaging is intended to be switched to use these systems and the initial clinical server will be retired. ePOC messaging will conform to HL7 Version 3, which initially will use only XML encoding [10]. The XML tags in a Clinical Document Architecture (CDA) document are defined by the HL7 Reference Information Model (RIM) which is based on a variant of Unified Modeling Language (UML).

CDA is based on the RIM and uses V3 data types and methodology. It contains many optional data elements and data segments, making it adaptable to almost any site. This feature makes the decision to base messaging on HL7 V3 attractive to the ePOC project as it complements the ethos of the project in developing an application which is generic, scalable and adaptable. Further, "the Reference Information Model (RIM) is the cornerstone of the HL7 Version 3 development process. RIM is a large pictorial representation of the clinical data (domains) explicitly representing the semantic and lexical connections that exist between the information carried in the fields of HL7 messages" [9].

Apart from technical data management issues associated with transforming paper-based point-of care systems to electronic point-of-care systems, social issues (ethics, privacy and security) also exist which must be addressed in regards to the realignment of any newly proposed technology implementation at the organizational level.

3. Implicit Information Processes - Organizational Considerations

The mode of data access, collection and diffusion by TACT clinicians at point-of-care is obviously transformed by the integration of mobile devices such as PDAs. For example, recording a patient's blood sugar level (BSL) by entering the BSL directly into a preformatted field on a PDA differs from the present mode whereby the information is written into a field on a paper form. What is not so obvious, however, is the implicit change in the process of data collection and diffusion from an ethical and patient privacy perspective.

Permission for an Ambulatory Care clinician to access, modify and update patient information as part of delivering an episode of care currently (existing paper-based system) is deemed to have occurred when a patient agrees to be treated at point-of-care (i.e. the patient's residence or Ambulatory Care outpatient facility). This occurs as a subsystem of the referral process. The ethical connotation as relates to patient permission for a TACT clinician to use a non standard device (PDA) to access and modify their (patient) records was not predicted by ePOC systems designers at the time.

Upon reflection and advice sought under guidance from an overseeing Human Research Ethics Committee, ePOC developers became aware of such differentiation. A trail must be blazed by ePOC systems and it is the ePOC project team's belief that patient acceptance of PDA-based patient document management systems will gain acceptance by patients as they become accustomed to the technology and the benefits of deploying such devices, leading to improved levels of care, are made known through exposure to the new paradigm of ePOC systems.

This sampling of issues associated with the need to realign new technologies and processes with existing legacy document management and embedded institutional ethical/ legal information collection illustrates the complexity of developing mobile health information systems for Ambulatory Care. A field trial which attempts to proactively address these issues in a pragmatic manner is the ePOC PDA Project, currently under development for TACT (ePOC Client).

4. *e*POC: A Mobile e-Health Solution

Paper-based information available to a clinician at point-of-care is effectively limited to what the clinician is able to carry. The ability for the TACT clinician to electronically modify a patient record 'in the field' is not possible at present. Additionally, problems associated with paper-based exchanges, difficulty in deciphering hand-writing, lack of integration of information and limited availability and capture of information at the point-of-care have been identified [16]. *Electronic* Point-of-Care offers the potential to overcome these identified limitations of paper-based Ambulatory Care systems.

The ePOC PDA project is a collaborative research and development project between academic, health and health informatics partners. Researchers are drawn from three Australian universities; Wollongong University, Flinders University and the University of South Australia. South Eastern Sydney and Illawarra Area Health Service (SESIAH) perform the role of health partner, while Pen Computer Systems Pty Ltd, a leading Australian-based health informatics company, performs the role of technical partner.

The convergence of information and communication technologies (ICTs) into a single

mobile device (PDA) may well be seen as a harbinger of viable mobile e-Health solutions for community-based healthcare services. PDAs as platforms for mobile-based *hospital* clinical information have "proven to be among the most cost effective ways to improve patient care quality and reduce medical data collection errors" [13]. Studies of such usage within hospital environments are plentiful [2, 11, 12, and 13]. However, studies which explore extending PDA usage into Ambulatory Care service settings, as an *electronic* point-of-care application are scant.

With the process of digitization, any information can be delivered through any medium with the user deciding what form it takes [17]. A PDA-based point-of-care system is significant because it provides for the collection, delivery and exchange of timely information (both text and images) at the point-of-care. Such a system provides natural advantages over the existing paper-based clinical and administrative collection systems. The Health Informatics Society of Australia broadly defines health informatics as "an evolving socio-technical and scientific discipline that deals with the collection, storage, retrieval, communication and optimal use of health related data, information and knowledge" [7]. The ePOC PDA project is in effect, an applied paradigm of health informatics. The broader aim of the ePOC system is to become the archetype, a prototype for the access and diffusion of clinical Ambulatory Care data at point-of-care.

TACT has a requirement to enter data at the point-of-care about a patient condition and the clinical activities carried out during the ambulatory visit. This will be provided by an application on a PDA that synchronises with the required health information database(s). The evaluation of the PDA system in the ambulatory care environment provides a central platform for the research and the measurement of its impact on ambulatory clinical practices.

The ePOC information solution as illustrated in Figure 1 consists of four steps:

1. Query to PIMS (Patient Information Management System / HOSPAS Equivalent) for all Patients discharged in the last 24 hours
2. Demographic data for Patients returned via e*Gate
3. Appropriate Patient information is sent via the HL7 Messaging Gateway to the PDA
4. Updated Patient information is sent back to ePOC via the HL7 Messaging Gateway

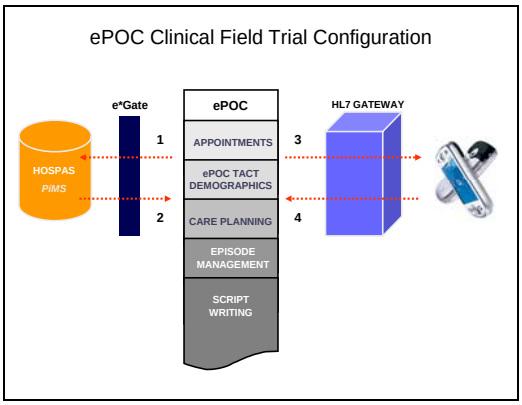

Figure 1: Illustrated ePOC Information Solution

5. Project Methodology

ePOC is a multi-phase, iterative R&D project with a research focus including, but not limited to: Pre and Post-Implementation technology implementation framework analysis, a detailed clinical workflow study, the investigation of end-user perceptions of clinical mobile health information systems, the iterative evaluation of user acceptance by the client (TACT), and the exploration of technical issues involving human computer interface development and evaluation, database schema browsing, document management, rapid application development and human-centred design.

An initial ePOC feasibility study of a prototype PDA based health information system for TACT was conducted in 2003 [18]. The identified benefits of this study included: supporting critical workflow activities, addressing operational inefficiencies (by automating and streamlining workflow activities) and increasing access to patient and medical information at the point-of-care. Additional requirements were also noted including: data entry audit controls, patient allergy reminders, data formatting standardisation, patient record search (database query), GUI design, data sharing interface, patient notes, controls and search mechanisms, usability issues, and changing and unpredictable datasets [18]. In its implementation, ePOC addresses the difficulties of federating disparate data, HL7 messaging and the limitations of the mobile platform within a practical community clinical health service environment. ePOC is intended to address the mobile clinical information needs for TACT clinicians and allied-health professionals.

Electronic Document Collection: End-User Implications

In order to achieve best fit between a PDA-based health information system and end-user (clinician), issues of user acceptance must be identified and mitigated with change management strategies. An assortment of existing paper forms utilized for patient data collection can easily be mirrored as proformas for deploying on a PDA in electronic format. An associated process however, was a review of these current forms (their structure, data flow, legal data gathering requirements and data field integration into appropriate back-end health systems. In this way, the electronic versions (proformas) are deemed to be the most appropriate data collection method at the time. This approach can then be refined during the course of clinical trials before the delivered system becomes operational. An electronic information system replica for TACT could be developed in a short time. Such a situation should minimise the risk that the desired delivered system will not meet organizational, operational or more importantly, end-user requirements.

Anecdotal evidence abounds of poorly planned systems integration projects which are doomed to failure. The ethos of the ePOC PDA project is that with forward thought and proactive approaches (including iterative consultation) instigated by the systems development team, user acceptance can be improved and ownership of the delivered system taken by clinicians as a result of being involved in a nontrivial manner during all phases of system development. Additionally, this approach helps address the issue of the varied computing skill levels of the TACT members.

A combination of structured methodological approaches including focus groups, information and question and answer sessions were conducted during the pre-implementation phase of ePOC. End-users gained an understanding of the proposed system by interacting with the ePOC prototype, deployed during an initial feasibility phase of the project. Concerns regarding not having a complete working system to base perceptions upon are not an issue for the ePOC system developers. Developers instead followed Davis and Venkatesh's hypothesis "that stable and representative measures of perceived usefulness only require that potential users be informed of what a system will be designed to do, i.e., its intended functionality, and do not require hands-on interaction with a working system" [4].

It is evident ePOC will transform the workflow for TACT clinicians at point-of-care, however, administration and management personal also stand to benefit from ePOC by the utility of data the system will provide in relation to organizational and operational statistics and integrated reporting. These components of TACT are performed manually, in a time consuming manner, at the end of each month or specified reporting period. On occasion, reports are requested by Area Health Service managers on an ad hoc basis. ePOC can satisfy such requests in a far timelier manner than would presently be possible by administration personnel.

6. Conclusion

This paper has outlined several intrinsic considerations which arise in the development and proposed subsequent integration of PDA-based mobile document management systems designed for deployment within Ambulatory Care service settings. Many of the issues described manifest themselves as a result of the misalignment in *service* and *information management* models utilised by community health services such as Ambulatory Care and HITH.

Health systems by their very nature are fundamentally dynamic in nature, evolving over time, consisting of a mixture of legacy, integrated and stand alone systems; the development of which are constrained by the need to extend resources under tightening budget constraints as the Australian population ages and further burden is placed upon existing health services. A PDA-based e-Health solution which achieves a 'best fit' for TACT clinicians by addressing the alignment of *service* and *information management* models of community health care leverages ICT to improve clinical information access and diffusion under such identified constraints.

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