Investigating The Potential Improvement of Patient Management Systems In Hospital Ward Settings Using Mobile, Wireless Technologies

Linda Dawson
Monash University,
Caulfield, Victoria,
3145, Australia
Phone: +61 3 9903 2415
Fax: +61 3 9903 2005
Linda.Dawson@infotech.monash.edu.au

Julie Fisher
Monash University
Caulfield, Victoria,
3145, Australia

Liza Heslop
Monash University
Caulfield, Victoria
3145, Australia

Abstract: *Wireless networks, hand held devices and associated applications are key emerging technologies ideal for nomadic workers such as clinicians in ward settings. They can potentially enhance clinicians' use of patient management and clinical systems by providing decision support and clinical information exchange at the bedside or point of care. Empirical research is needed to better understand and implement this potential improvement in patient management systems. This paper describes some preliminary findings of a project which aims to understand current ICT-based work practices and expectations for wireless, mobile environments in an acute ward setting; select and install appropriate wireless information communication technology (ICT) devices and applications at the bedside in a clinical ward; and to conduct an action research study to monitor the utility, user acceptance, security and safety of that technology at the bedside for patient management.*

Keywords: Hand held devices, Mobile devices, Nomadic, Healthcare, Patient Management

1. Introduction

Poor access to information such as diagnostic results can mean delays in clinical decision making. Delays in clinicians' workflow processes are compounded by clinicians' poor access to computers and/or their lack of confidence in the ability of information technology (IT) to positively affect clinical outcomes. Delays may also result because clinical staff do not use existing patient management and clinical systems effectively or are frustrated because the information they need is not available at the point of care.

Wireless networks, hand held and portable devices and associated applications are key emerging technologies ideal for nomadic workers such as clinicians in ward settings. They can potentially enhance clinicians' use of patient management and clinical systems by providing decision support and clinical information exchange at the bedside or point of care (Al-Ubaydli, 2004; McAlearney et al., 2004; McLeod et al., 2003). Such technologies need to be critically assessed in a hospital environment for their wider potential and application for the delivery of information at the point of care.

This paper describes some preliminary findings of a project the aims of which are to:

- Analyse the current clinical ICT environment and work practices in a typical acute ward setting
- Describe and install a wireless infrastructure and introduce the latest wireless information communication technology (ICT) devices and applications at the bedside in a clinical ward to support patient management work practices
- Conduct an action research study to monitor the utility, user acceptance, security and safety of wireless ICT devices and applications at the bedside for patient management

2. Background

Most health-care workers could be described as "nomadic" in their daily working environment spending considerable time moving around with little opportunity to interact with a desktop PC. Nomadicity or nomadic computing is defined as the systems support needed for providing " ... *computing and communication capabilities and services to nomads as they move from place to place in a transparent, integrated and convenient form*." (Kleinrock, 1997). As a way of addressing the nomadic nature of clinicians the use of PDA devices is growing in popularity amongst health care professionals (Crook & Woody, 2003; Scordo et al., 2003; Shipman & Morton, 2001). McAlearney et al., (2004) in a study of doctors' experiences with handheld computers in clinical practice suggest that users perceived that mobile devices aided in increasing productivity and improvements to patient care. They also suggest that *"Key opportunities with handheld computers include[d] their use as a stepping stone to build doctors' comfort with other information technology and ehealth initiatives and providing point of care support that helps improve patient care."*

Yet many factors have hindered the implementation and use of information systems in a hospital environment (Minard, 1999). Clinicians may resist the 'liberalisation' of patient information and often raise concerns about patient confidentiality and security of data. Problems arise, too, because clinical information systems affect existing structures of health service organisations and the functions that such organizations must support are complex (Anderson, 1997). Also hospital IT departments are generally under resourced and few have the opportunity or funds to experiment with new technology.

Poorly integrated systems in healthcare environments also discourage and hinder the sharing of information (Poon et al., 2004; Rowe & Brimacombe, 2003). Fernando (2004) suggests factors such as poor data quality, conflicting systems architectures and data fragmentation contribute to lack of integration in health information systems (HIS) particularly with regard to systems security. Specific to ward-based HIS Timmons (2003) found five specific criticisms by nurses of IT infrastructure:

- Using the system is time-consuming and "there is a lot of wasted time"
- There are not enough terminals (often due to financial constraints)
- The IT systems create large records and waste paper because "it is easy to just continuously press print"
- Users are too easily interrupted because "terminals were most often sited at the nurses' station, usually in the busiest part of the ward" where "patients and relatives do not see using the computer as 'real work'"
- Reliability of the system – if it goes down or is very slow to respond there is no access to patient details

Some of these issues also apply to hand held devices. Additional barriers include physical limitations of the device including small screens which hinder the presentation of information in a meaningful and accessible way (Albers & Kim, 2000). Constraints caused by small keyboards or stylus data entry can provide a negative impact on data integrity (McAlearney et al., 2004). Mobile device use by volunteers in one clinical trial (Koop & Mosges, 2002) found users had problems with data entry which resulted in missing values and this problem was compounded because the system did not notify users of missing values. Error rates were also high because the application was not able to handle the speed of users' data entry. Hospital paper records are valued by clinicians and their replacement may not be widely accepted by them. Luff and Heath (1998) argue that the success of the paper record is because it supports both synchronous and asynchronous collaboration between doctors, patient and other medical staff and paper records can be moved around, within a hospital. How applications for mobile devices are designed will inherently differ from the approaches used to develop PC based applications (Dix et al., 2000; Wasserman, 2000). In the health care environment there are specific application and development challenges, including storage and transfer of data, how easy devices are to use and building applications to suit the work environment (Checkland, 1981; Dawson & Fisher, 2004a; Dawson & Fisher, 2004b; Dix et al., 2000; Shipman & Morton, 2001).

Identification of these and other issues indicates a need for rigorous research into all aspects of introducing mobile devices and mobile information environments in healthcare environments.

3. Research Approach

3.1 Research Objectives

The aim of this research project is to identify issues in ICT-based data collection activities in an acute ward setting and to address those issues by proposing the establishment and testing of an appropriate wireless infrastructure.

The specific research questions are:

- "How are work practices, especially ICT-based data collection activities (from admission to discharge), currently carried out in an acute ward setting?"
- "How could current work practices at the bedside in a clinical ward and ICT environments be improved through the installation of a wireless infrastructure and the introduction of the latest wireless information communication technology (ICT) devices and applications?"

3.2 Case Background

Ward Description

The Neuroscience ward has 30 beds. There are notionally three units containing 16 neurosurgical beds, 4 neurology beds and 10 stroke beds but these numbers are flexible depending on patient needs. The neurology and stroke units tend to be occupied by patients who are predominantly emergency admissions and the neurosurgical patients are a mix of elective surgery and emergency admissions. There are 42 effective full time staff (EFTS) which comprises 59 nurses and 6 registrars within the 3 units and 4 resident medical officers. The resident medical officers turn over every 2-3 months. There are also about 30 allied health professionals – physiotherapists, occupational therapists, speech pathologists, neuropsychologists, social workers, dieticians etc. all rotating through the unit at any one time. So there are large numbers of staff who need to access the same records and the same data to track the patients.

Data Collection

The first two stages of this project are underway. Interviews and observations both on the ward and at project planning meetings have been conducted with key personnel regarding the current clinical ICT environment and a proposed wireless environment. These interviews and observations have provided the preliminary findings discussed in this paper. Key personnel include the Nurse Unit Manager (NUM) of the ward and the Stroke Liaison Manager (SLM).

The NUM manages all patients on the ward and the SLM's main role is to help progress the stroke patients through the unit. He also supports the NUM in the management of stroke and helps develop new initiatives in the assistance in managing stroke patients.

ICT Infrastructure

The NUM and SLM have been investigating the possible use of mobile devices on the ward to improve the delivery of patient care. They have had discussions with IT professionals and researchers about a potential wireless infrastructure. The current and proposed infrastructures are outlined in the following table.

Current ICT infrastructure	2 PCs used by all staff clinical and administrative - one in the nurses' work station and one in the unit manager's office. Pagers, fax and deskbound phones. Some clinicians use mobile phones.
Proposed Wireless Infrastructure	4 PCs, 3 wireless base stations, 2 wireless laptops, 1 wireless tablet PC (for displaying x-rays in particular), 1 ruggedised PDA (including bar code reader), 1 customised trolley for moving the laptop around the ward, 3 wireless IP phones

Table 1 ICT Infrastructure

4 Findings

4.1 The "Patient Journey"

The concept we will call a "patient journey" underpins much of the approach to patient management on the ward. The Unit Manager manages the "throughput" of the ward

> *"If you were to compare (the SLM) and my roles I am the quantity and (the SLM) is the quality. I have to manage the throughput through the ward. We have our paper medical records into which everyone enters data. We receive information about patients, clinical information from the computer system - outdated but functional ... We have recently gone on to a web based [system for] diagnostic imaging reports and visualizing X-rays etc [the PACS system] but all of that information which is stored and retrieved in a variety of different ways assists with, from my perspective "throughput" - getting patients in and getting patients out on the business side of things. So the information needs to be available in order to make the decisions whereas (the SLM) is able to manage a smaller cohort of patients and look at the process on which the individual patient is managed. I get the macro, (the SLM) gets to look at the micro."*

The SLM is specifically interested in collecting data on *" ... how patients travel through the service, what the time frames are for that service, what kind of clinical assessments have been done for these patients, what are the risk factors, treatment plans, what investigations they have had done as well as looking at the projected outcomes of these patients based on the data."*

4.2 Triggers

Another major management concept is "triggers". The first major trigger is when patients are admitted (emergency or otherwise). Results of a vital signs check (daily, half hourly, depending on the patient) can trigger specific processes and procedures. Various procedures which might be recommended as part of treatment, such as MRI scan, X-ray, pathology etc are triggers for changing data. Clinical assessment may trigger which therapist is required e.g. referral to allied health.

4.3 Clinical Support Processes

There are various procedures and processes that are part of the work environment on the ward. In this paper we will focus on the most common processes and procedures and also those which have an IT or potential IT component. Pathology is the most commonly used service on the ward by both nursing and medical staff. The next most common is X-rays. The ward uses a multidisciplinary team approach for day-to-day patient management. Each process uses varying degrees of IT infrastructure. We also explored the expectations of the staff regarding the potential application of mobile, wireless technologies to these processes and procedures.

Current Pathology Process

The pathology process was described as:

> *"Doctors have to write a pathology request. That pathology request would then be stored on the ward and there is a floating pathology service in the hospital so there are (sic) a team of nurses taking blood samples. We would store all the requests on the ward. The blood sisters would come up and get the requests and then go round and see all of the patients."*

The process has recently changed slightly in that

> *"... the doctor still writes requests but overnight the night staff gather up all the requests and send them down to the pathology department. Pathology is a 24-hour service but overnight there is less for them to do. So a lot of the down time in pathology is now spent pre-registering all of the patients' pathology requests."*

So for patients who need blood tests in the morning the pathology department provides a computer print out listing all those patients in bed order. This streamlines the process so that nurses can take blood specimens working through the ward bed by bed based on the computer-generated list. The specimens are then delivered to the pathology department where they are bar-coded and the tests are done straight away. This is the first step towards electronic ordering of tests which is one of the KPIs required by the Department of Human Services (DHS).

Expectations – pathology process

The introduction of a computer printout for blood tests has helped in the introduction of an electronic based pathology process. Ward staff have become comfortable and confident with the use of computer-based printouts and this eases the transition to an electronically ordered system.

"Instead of ordering tests on paper they will be electronically ordered into the system and that would save even more time. So that would be the next step. I think that the culture has already looked at ways we can move with the times. But we don't necessarily have the IT support to be able to implement those processes. We will be able to do that [with mobile]. So if there is going to be a trial of electronic ordering then we will be the people who will be doing it. And that is going to be driven by DHS from the top down and we are in prime position to be able to do those trials. And that will be very healthy and help to more easily give us measurable outcomes."

Current X-ray Process

The X-ray process has also recently changed. There is now a new electronic reporting system based on Picture Archive and Communication System (PACS) which provides the processed digital images (ideally) before the patient reaches or returns to the ward. The system also provides formal reports delivered electronically. *"It is still in its infancy and doesn't work every single time. Once it's bedded in you will get the image and the formal report before the patient even gets back to the ward. The images system works but the reporting system is just being rolled out.*"

The formal reporting system requires a doctor (radiologist) to be available to read the image and create the report. The radiologist dictates the report on to a voice recognition system. So the provision of the report is very much dependent on the workload in the medical imaging department. Often an unauthorised technician's (radiographer) report is available almost immediately but the official report is not available until the radiologist has had a chance to read the scan – usually some hours afterwards. The unit manager suggested that this provided a more interventionist approach:

"Diagnostic imaging is very much an interventionist thing now so the medical staff are actually involved in direct patient management. Not just reading reports and looking at x-rays. They actually intervene in performing the task. So it is a much more medically focused speciality. It's not just technology driven it is medically driven down in the medical imaging department."

"And in our speciality, the medical staff - the neurologists and neurosurgeons - don't necessarily want the report - they want the images, they are going to act on what they see – not what somebody else has seen. And so we have everything available electronically and no matter where they are on the system they can just type the patients UR number, you know, on the web and they can bring up the view (image) themselves. So we don't have as many x-ray printed as hard copies as we used to – they are available electronically."

Expectations – X-ray Process

The NUM and SLM expect that the bedding in of the electronic imaging system combined with mobile technologies will provide greater efficiencies *"... it will save a lot of nursing time spent chasing hard copies ... they [clinicians] can get it in their office, get it in the ward etc and review the images"*. There will no longer be cases where *"... if you can't find the film you have to send your patient down for another x-ray in order for them to be able to have a procedure done. Which we use to have – people would have repeated procedures because nobody could locate the film."*

It is expected that images will be available to clinicians by email at other hospitals and eventually via mobile technologies both on the ward and remotely. *" ... most medical staff have toys. They can receive images. They could be consulting [elsewhere] ... and could say, 'Quick! Send it [the x-ray] off, get the patient to theatre. I'm on my way'. That [aiding in emergencies] is a potential that will be realised fairly quickly – we are heading in that direction because it is accessible now ... because people with mobile technology are out there. So they can receive the image where they are if you can get it out there."*

4.4 Managing Patient Information

Admission Process

Every patient who is admitted to the hospital has to go through a formal admission process. "*They can enter the hospital from a variety of avenues - by ambulance direct to the ward; they can come through the emergency department; they can be an elective admission or something that is planned but there has to be an admission process."* This is the initiation of the patient's medical record. The medical record is viewed as "continuous". Everything that happens becomes part of that record. But " ... *having a paper record is not the easiest way of finding out information, often it gets lost and everyone uses a different format for recording*."

Data Collection

The main data are usual clinical data such as vital signs, pathology, radiology, medication, treatment plans, length of stay, and diagnostic history. But clinical data is seen in a holistic context with social data.

"Social information is important. We need to know how well the patient is supported at home. We need to know what services are available at home. So if someone is going home do they have counsel services, visiting nursing service, physiotherapist, case worker in the community? We need to know what that is. None of those services communicate with each other. So it can be a huge issue for us. So if there is a way of electronically capturing the discharge environment or resources in use that would save an enormous amount of time."

Electronic data collection is not yet in place although there has been some trials of a staff roster system and a patient dependency system " *... where all that data had to be put in on every shift and from minute to minute you had to record what the reality was - not at the beginning of the shift but everything - if someone went off sick. It required the effort of staff to put that information in. But it had robust data."*

Bar Codes

Patients have a hospital patient number which is bar coded on their wrist label. *"We don't use the barcode as such but one of the tools we have been trialling (using a PDA) has the capacity to barcode the patient and get data up on the screen and that would be the system you would be looking for if you are going to do pharmaceutical studies.*"

Barcodes are used in the hospital for other things. Not just to identify the patient. The medication storage system is bar coded. Pharmacy staff use a scanner to measure stock levels on the ward and then order drugs for the ward. Supplies are stored electronically in the Pharmacy by barcode and everything has an ID number. Ordering is done on-line after someone does a manual stock count. Electronic ordering by monitoring stock levels is not yet in place although *"The process is there ready to go but at the moment a person is using their time to look at what we need and ordering things individually. But the facility is there to do it – it just has not been put in place.*"

Patient Records

There is no written standard for maintaining patient records. "*Doctors assess patients the way they are trained to do it - they go through a systematic approach as to how they assess the patient. The nurses do it the way that* ***they*** *were trained.*" Patient practice notes are kept on this ward in consecutive order. If a doctor sees a patient and makes a record and the next person to assess the patient is a physiotherapist, those records are kept in a consecutive manner. Nurses evaluate the care they have done for that patient. Everyone writes one set of notes. Some disciplines keep other sets of notes but everything goes into the one record eventually. "*At the moment it is stored in one big diary and looks like a holocaust. We are obliged to keep it 7 years. It is all paper based. The records are electronic but the diary records are manual.*"

Multidisciplinary Meetings

The three units on the ward look after patients with very complex care needs requiring *" ... the full range of every allied health professional known to man – all ward based*". Because patients move through the system so quickly each step must be planned by all the staff involved. So there are daily multidisciplinary meetings and hand over where patient needs for the day are discussed. A reporting program has been set up on a laptop by the SLM so that minutes can be taken at these meetings. While this document cannot be entered straight onto the medical record it can be printed onto a progress page which can be inserted into the paper-based medical record.

In the handover process only a subset of the larger patient record is used although nursing staff have access to the complete record and set of notes for reference. Nothing is recorded electronically only the reports that are generated on the laptop. Nurses get an A4 double sided sheet listing the patients who are on the ward. The document is created on a PC and is updated by the nurses on every shift.

Data sharing is seen as important and crucial to the success of this approach: "*We have our multidisciplinary meetings. Some [allied health professionals] ask the same question in a slightly different way and get a different answer. We might have collected next of kin data but they might know that the next of kin might have recently had a hip operation and cannot manage the patient at home or the next of kin might have a cognitive problem and not be the most relevant person. So it is collected through different eyes. So if the information could be stored collaboratively so that we all get the benefit of the flavour in the way in which the information is received. ... Information is shared with each other. But we have to gather it separately*."

Expectations – Data Management

The NUM and SLM are hopeful that the integration of appropriate ICT including mobile, wireless technologies will offer several improvements in patient care. Bar code matching between patients and medications and procedures should assist in reducing medical errors. Digital imaging and electronic documents and records available online or on mobile devices should save time currently spent paper chasing. Integrated ICT across the ward and the hospital systems should assist in increased sharing of data and information between all health professionals on the ward.

4.5 Technology

Pagers

Medical staff and senior nurses on each ward have pagers allocated to them but do not always use them. Communication with medical and allied health staff " *... because they are much more roving population*" is via alpha-numerical paging using a land paging system where callers can leave messages instead of paging and expecting a return call. "*We leave a message so that they know when they ring what they are ringing back for. That is a fairly new innovation here at [the hospital] but has been used elsewhere for some time*."

Mobile phones

Some staff and most specialists have mobile phones and although there are signs asking for mobile phones to be turned off in the ward, they are mostly ignored by doctors. It is not so much the technology interference that people worry about but "*It would be pandemonium if every patient and relative had a mobile phone. It is more for the control of the environment."*

Desktop PCs and Laptops

There are 4 PCs on the ward and 2 laptops – only one of which is in constant use because of networking problems. There is also a tablet PC for viewing x-rays, but this is still to be set up properly. Access to computers is always a problem. "*We have more computers than any other ward except Intensive Care and we are quite privileged in that regard – but we have so many people who want to use computers. It doesn't make it any easier. We almost need one for everyone on the floor [because of the turnover of personnel] ... no matter how many [workstations] we have people still want a computer they can use and they cannot get on to them when they want them. There are issues of logging on and off; having your own passwords; having things opened that everyone can access; security issues. ... That's a huge can of worms and at the moment our system is very slow and it doesn't meet our needs*."

Fax

Faxes are used extensively both from PCs and a fax machine. Information such as assessments, medical discharges and findings are faxed to GPs, other departments and clinicians.

Expectations - Technology

Smart IP phones have been installed but are not used much yet *"... staff need to be told how to use them properly*". Although there are 4 PCs and 2 laptops available only one is in use because of networking issues. These all need to be brought on line using the proposed wireless infrastructure. The tablet PC for viewing X-rays has been working intermittently but still needs to be configured to work properly with the PACS system. There is also a ruggedised PDA which can read bar codes with an infrared reader but this also needs to be set up properly after some initial trials. *"... we have access to those things but we are not using them yet."* The NUM and SLM are reticent in getting clinical staff to use any of the technology until it is set up so that it is reliable and *"... works all the time"* because doctors will not come back and test the technology if it has proved to be unreliable before. The main expectation is that information and documents including images will be available "anywhere, anytime" on the ward or to ward personnel in other locations via mobile and wireless technologies. It is just a matter of getting the infrastructure right and convincing the staff to try it.

The overall expectation is best summed up by the SLM: *"My expectation is on two levels. I have a sort of utopic [sic] expectation of the future and the plan we are heading towards and behind that is a realistic expectation of going through certain steps. The utopic expectation from me is that we would do a ward round or some kind of daily assessment of patients and we could do it all at one time – we could see the results, we could see the investigations, we could see what drugs they were on, we could access an outpatient data base; we can arrange the admission appointment, we can arrange discharge medications and send the prescription off. So, we could see that patient and discharge that patient within 5 – 10 minutes at the bottom of the bed where the care is being given – point of care treatment at the bedside. And we can do all that as a team of medical staff and then move on to the next patient…. That is utopia."*

5 Discussion

The introduction of any new technology in a complex environment such as a hospital is will invariably be slow as this case illustrates. The enthusiasm and persistence of the NUM and SLM in this case are key factors for success. They are positive and cautiously optimistic about improvements being achievable on their ward by the appropriate application of new ICT. An analysis of the findings has identified the following main issues and potential improvements that may be gained by additional ICT infrastructure which is primarily wireless and mobile.

Frustration

Currently many staff are competing for a small number of fixed workstations leading to high frustration levels. There is also a lack of IT infrastructure and support adding to that frustration. The IT budget is under resourced which leads to delays in maintenance and update of systems. When there have been trials of new systems they often take a long time to fully rollout. These findings are similar to Timmons (2003) earlier findings that when clinical staff become frustrated with access, usability and reliability of IT infrastructure their attitude becomes (or appears to become) one of resistance and includes attempts to minimise the use of the system. However, we suggest that in the case of ongoing problems with access, usability and reliability that it appears to be more a "cause and effect" result rather than resistance to the technology or IT-based work environment per se. It will only be when these problems have been addressed and solved in terms of easy access, appropriate usability interfaces and reliable systems that research can be focussed on the difference between resistance and reactive frustration. This project will be addressing this issue in future research.

In this case staff would like to see additional ICT infrastructure including the mobile wireless infrastructure that has been proposed. They would also like to see planned rollouts that they have some stake in. Personal ICT environments would be the ideal environments for many staff if they were achievable. Further, the staff have identified where use of the currently available technology, such as the bar codes, could be expanded and this is also leading to frustration in not being able to act on good

ideas due to lack of IT resourcing. As the additional ICT infrastructure is rolled out research will continue to better understand the real sources of frustration and perceived resistance.

High need for communication technology

The personnel working on the ward are highly nomadic (Kleinrock, 1997) in a variety of contexts – within the ward, within the hospital and within the wider healthcare regional network. Currently there is extensive use of deskbound phones, pagers and faxes and some mobile phones (which are not supposed to be used). For the work of the ward to be carried out efficiently these nomadic staff need to be in constant communication with one another. Little research appears to have been carried out which addresses communication needs for nomadic clinicians. We believe that this issue needs to be fully understood and addressed as a specific layer of work practice which has evolved because of easy access to mobile phone and paging technology. That is, that current work practices are predicated on the expectation of easy, fast and reliable communication technology in various forms – voice, paging, email, SMS, MMS etc and that the absence of reliable communication for nomadic workers actively and seriously hinders successful work outcomes.

The proposed wireless infrastructure in this case is intended to provide a reliable communications environment for nomadic clinicians. Additional infrastructure includes IP phones, ruggedised PDAs and mobile laptops possibly on purpose-built trolleys. These technologies need to be tested in the ward environment to see whether they can deliver the data management and communications needs of the stakeholders. Hybrid devices (phone and PDA) capable of receiving appropriate documents and information may be appropriate technology worth testing in this environment.

Lack of integration of paper-based processes and ICT infrastructure

This case study's findings have similarities to other recent findings particularly with regard to the need to improve access to and sharing of clinical information (Fernando, 2004). Improved integration of paper-based and electronic information systems is crucial to the improvement of point of care decision-making and patient care practices (Fernando, 2004) and higher level integrated care initiatives (Rowe & Brimacombe, 2003).

In this case the recording of patient care activities is currently done using paper-based systems at the bedside, or the point of care, and the paper-based information is not easily integrated with the current fixed ICT systems which hinders effective data sharing. The medical record is maintained electronically but with some time lag while current patient notes used for handover and day-to-day management tend to be in note form or a paper diary. Information in the diary should eventually make its way into the electronic record. Any analysis of data may require a trawling of handwritten notes which makes analysis very time consuming. The lack of data integration, caused by the problematic interface between paper-based and electronic information systems, is seen by staff as a major area which needs to be addressed. Further, the delivery of test results to the ward in hard copy can lead to lost information and duplication of tests such as x-rays and scans. These findings confirm common issues of dissatisfaction and the need to improve delivery methods for test results (Poon et al., 2004).

Planned integration of systems such as the digital imaging system while acknowledging the context and appropriate needs for soft/hard copy should improve patient management and care. An analysis of achievable data collection processes using wireless systems and integration of data with wider hospital data management and patient record infrastructure should also lead to improved patient management at the point of care. As discussed above (Dix et al., 2000; Wasserman, 2000) the design of applications for mobile devices will be inherently different from those designed for paper-based or PC based applications. Whether the goal of "Utopia" can be achieved will require further research, testing and analysis.

6 Conclusions and Future Work

This paper has discussed the need for empirical research into use of mobile devices for improving patient management at point of care. The project described in the paper is a study of a ward setting as it goes through the process of setting up and using mobile, wireless technologies at point of care. The proposed method for exploring a proposed wireless, mobile clinical environment must start by understanding current ICT-based work practices and expectations for wireless, mobile environments and then plan and monitor the introduction of the new mobile technologies.

The implications of this research, so far, are that current ICT environments in clinical wards may not be being fully utilised to enhance patient management at point of care due to barriers to usability and accessibility both to appropriate technology and consequently appropriate information needed for high-level, high quality patient management. There are implications also that the introduction of mobile, wireless technologies may deliver anticipated improvements in patient care as long as security and usability issues can be addressed.

The next phase of this project involves the setting up and monitoring of a wireless environment based on a proposed infrastructure, some of which has been outlined above. An action research study will then be conducted to analyse and monitor the introduction of the wireless technologies in various configurations to establish which configurations best support and improve work practices where appropriate and where possible.

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