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Abstract

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Keywords

ward, mobile, environment, creating, hospital, information, emerging, health, research, action, technologies, systems

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Action Research in Emerging Technologies in Health Information Systems: Creating a Mobile Information Environment in a Hospital Ward

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Abstract: Wireless networks, mobile devices and associated applications are key emerging technologies ideal for nomadic workers such as clinicians in hospital ward settings. These mobile information environments can potentially enhance clinicians' use of patient management and clinical systems by providing decision support and clinical information at the bedside or point of care. Such technologies need to be critically assessed in a hospital environment for their wider potential and application for delivery of information at the point of care. This paper describes the use of action research methods in a project which analysed an existing clinical Information Communication Technology (ICT) environment in a typical hospital ward setting and the implementation of a mobile infrastructure to support patient management. The research found that although many of the clinicians acknowledged the usefulness of the devices there is a high level of scepticism, concern and "resistive compliance". There were also concerns over change management and training. From the findings, we propose a holistic approach to the introduction of mobile wireless technologies in hospital ward settings based on a variety of activities that need to be undertaken in the implementation environment for successful adoption of these technologies. The action research approach used in this project was found to be a useful approach for understanding the implementation of emerging technologies in a hospital environment provided stakeholder analysis takes place early in the project.

Keywords: Action research, mobile devices, health information systems, hospitals, stakeholder analysis

1. Introduction

Wireless networks, mobile devices and associated applications are key emerging technologies ideal for nomadic workers such as clinicians in hospital ward settings. These mobile information environments can potentially enhance clinicians' use of patient management and clinical systems by providing decision support and clinical information at the bedside or point of care. Such technologies need to be critically assessed in a hospital environment for their wider potential and application for delivery of information at the point of care.

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 Personal Computer (PC). As a way of addressing the nomadic nature of clinicians the use of Personal Digital Assistants (PDA) devices is growing in popularity amongst health care professionals (Dale and Hagen, 2007; Khan et al., 2007; Lu et al., 2005; Rivera et al., 2008). 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.

However, clinicians often resist the use of new Information Communication Technology (ICT) (Minard, 1999; Timmons, 2003) and raise concerns about patient confidentiality and security of data (Fernando, 2004). Poorly integrated systems in healthcare environments also discourage and hinder the sharing of information (Poon et al., 2004; Rowe and 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. Dale and Hagen (2007) in their review of nine studies of PDAs used for collecting patient data found that all studies reported problems with the PDA technology.

Paper records are still highly valued by clinicians. 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. Although current research indicates the use of PDAs and other mobile devices used for providing patient information at the Point of Care (POC) can improve the quality of care (Baumgart, 2005), this could depend on several elements, including the type and number of applications available, the

technology competency of medical staff, and the perceived areas of patient care that will benefit from mobile technology (Rosenthal, 2003). A study by McAlearney et al (2004) found that although doctors expect devices such as PDAs to become more useful, issues around reliability, connectivity, usefulness and security still remain. Screen size of PDAs and the limitations this places on information presentation is also a problem (Guruajan and Murugesan, 2005). Other issues include data transmission problems and a lack of integration with other hospital systems (Guruajan and Murugesan, 2005; Istepanian et al., 2004). Further, the complexity of health care organizations, and in particular hospitals, requires organisational and cultural changes for the benefits of these technologies to be realised (Istepanian et al., 2004).

This paper describes the findings from an action research project which:

- Analysed existing clinical ICT environment in a typical hospital ward setting and explored expectations of clinical staff for the potential for mobile wireless ICT
- Implemented a wireless infrastructure and mobile wireless devices and applications at the bedside to support patient management and conducted an action research study to monitor the utility and user acceptance of wireless ICT devices and applications at the bedside for patient management

2. Background of the project

The project was implemented in a Neuroscience ward at a large public teaching hospital which has 30 beds. The nurses' desk on the ward had two desktop PCs, eight pagers, one facsimile machine and four telephones. In addition to 42 full time staff (nurses and registrars) approximately 30 allied health professionals – physiotherapists, occupational therapists, neuropsychologists, social workers, dieticians etc. rotate through the unit at any one time. This results in many staff needing access to the same records and data to manage and treat patients. The mobile-wireless infrastructure installed included, one wireless switch, three wireless access points, two wireless laptops, one wireless tablet PC (for displaying x-rays in particular), one ruggedised PDA (including bar code reader – used to retrieve and display pathology results), two customised trolleys for holding and moving the wireless laptops around the ward, and three wireless IP phones (Heslop et al, 2009).

3. Research approach

3.1 A framework for research

This research project was particularly interested in how new emerging technologies are accepted by clinical staff on a hospital ward. Research has shown that new technologies are often resisted by staff where they are seen as interfering with traditional clinical practice (Anderson, 1997; Timmons, 2003). Timmons (2003) studied nurses' resistance to the implementation and use of computer systems from a sociological perspective. He found "resistive compliance" where the "*... reasons for resistance are to be found at the interface between system design, on the one hand, and nursing culture and practice on the other*" p. 267. This sense of compliance aligns with an earlier study by East and Robinson (1994) who suggested that nurses "*... were not actively sabotaging these new developments as sociologists have described ... rather there was a sense of resignation, on the whole, and, amongst many of the staff, a grudging willingness to 'give things a go'.*" P 58. Timmons (2003) found three types of behaviour by nurses when using IT infrastructure:

- **Refusal to use the system:** rare but can occur when an individual is in a position of power, for example, a ward manager
- **Attempts to minimise use of the system:** not completing tasks especially entering paper-based data such as evaluations into a computer system; delaying the completion of tasks or leaving them for others to complete
- **Criticism of the system:** *The system itself:* wasted time, not enough workstations, creation of very large records (not possible with handwritten records), easily interrupted (at fixed workstations), lack of reliability (system going down regularly). *Security issues:* data entry by unqualified staff (ward clerks, health care assistants), sharing passwords and legal ramifications. *Nursing issues:* working away from the patient, nursing care models not correctly implemented, detracting from individualised care, degradation of nursing skills

Timmons' framework indicates that understanding underlying work practices in the implementation environment is critical to acceptance by users. In more general examinations of workplace technology

Suchman (1995) suggested that understanding work practices is important in realising the productivity of that technology. *“The way in which people work is not always apparent. Too often, assumptions are made as to how tasks are performed rather than unearthing the underlying work practices.”* (Suchman, 1995) p 56. Therefore, it is possible that resistive compliance may be overcome, or at least reduced if the implementation of ICT (in this case mobile wireless ICT) for patient data management is aligned as much as possible with underlying work practice. That is, a recognition and acknowledgement of the specific work place culture into which the mobile technologies are being introduced. Action research approaches can specifically address this issue by making the researchers part of the implementation while still seeking research outcomes (MacKay and Marshall, 2001). In this project researchers were part of the design and implementation team and brought a philosophy based on the importance of understanding work practices in new technology implementations.

3.2 Research method

This study used an action research approach based on a diagnosis phase followed by an implementation and monitoring phase. Data collection methods included: interviews (clinical managers and nursing staff), observation, meetings, and a survey of nursing staff.

The aim of the research project was to investigate the adoption of mobile wireless technologies on a busy acute medical hospital ward and within a ward-based work practice culture. The specific research questions were:

“How are ICT-based data collection and management activities (from admission to discharge), currently carried out in an acute ward setting?”

“Can ICT-based data collection activities be improved through the installation of a wireless infrastructure and the introduction of the latest wireless information communication technology (ICT) devices and applications?”

The action research method involves collaboration between the researcher(s) and the participant(s) and intervention by the researcher(s) in the situation being studied (Avison et al., 1999; Baskerville, 2001; Baskerville and Wood-Harper, 1996; Susman, 1983; Susman and Evered, 1978). In this project the Action Research cycle is adapted from (Baskerville, 2001) and (Susman and Evered, 1978), see Figure 1.

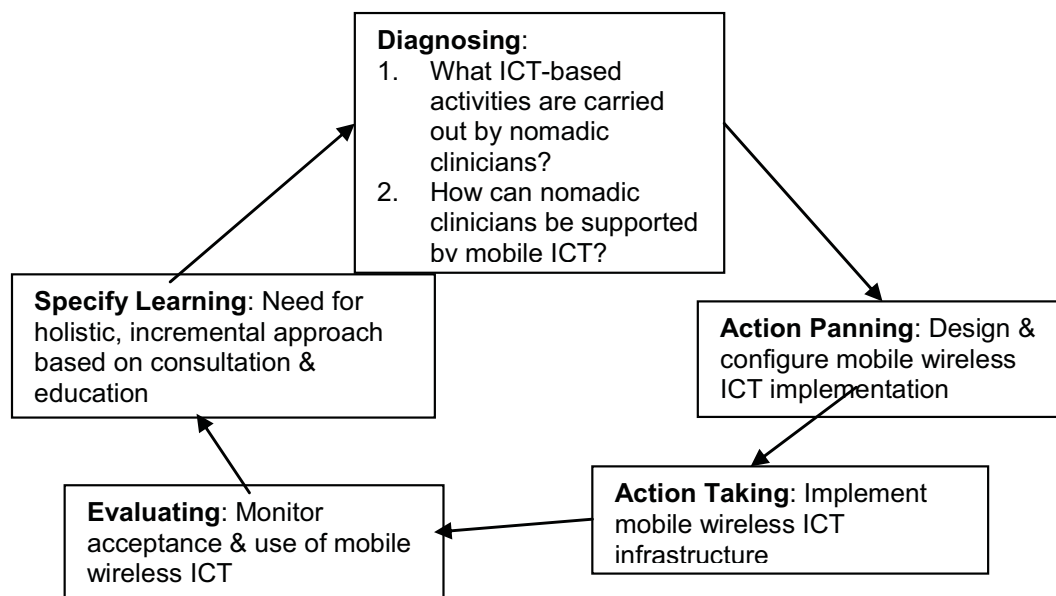


Figure 1: The action research cycle adapted from (Baskerville, 2001) and (Susman and Evered, 1978)

In the diagnostic phase of this study interviews were conducted with nurses and managers prior to the mobile wireless infrastructure being implemented. This work established the expectations and concerns of the managers and nursing staff (Dawson et al., 2005; Fisher et al, 2006). During action planning, action taking and evaluation phases a researcher worked on the ward with the managers and IT services personnel in configuring the system and the researchers held regular meetings with ward managers, IT services and industry partners who were supplying equipment.

A major issue emerged early in the design and implementation stage where it became clear that stakeholder analysis and management was necessary amongst the diverse groups involved to ensure that all perspectives were being considered. Many participants found that some time spent at project meetings was not useful from their own perspective. The successful resolution of this issue was based on setting up separate team meetings: the research team, the technical team and the project team, see Figure 2. Two researchers belonged to all teams. The project team consisted of most participants in the project: researchers, clinical staff and a technical representative. The research team meetings focussed on research issues including writing up the research for publication which was of little or no interest to the other teams. The technical team meetings were chaired by the lead researcher and dealt with specifically technical issues including the acquisition and deployment of equipment. Using this approach stakeholders were involved in the management of the areas of the project that aligned with their perspectives and desired outcomes and they were not spending time in meetings that were not specific to their perspectives and desired outcomes.

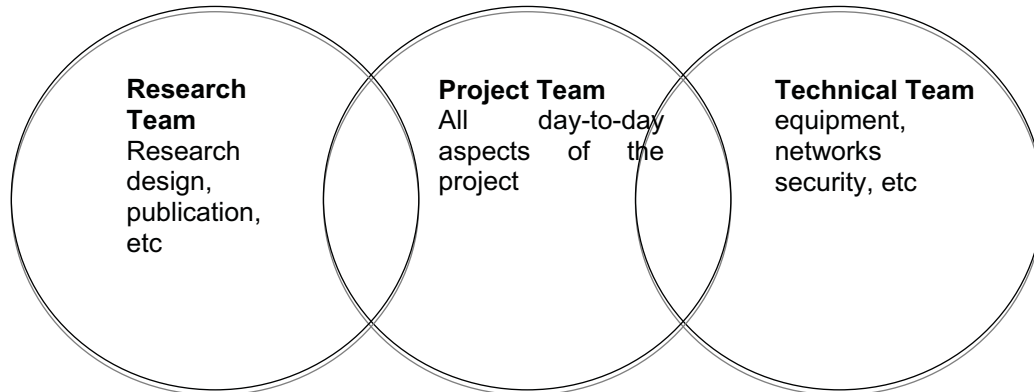


Figure 2: Stakeholder groups

During the evaluation phase data was collected over a period of 18 months and included interviews with nurses and nurse managers; and a survey of nursing staff. In addition a researcher worked on site with the participants providing regular journal of observations during implementation and notes were taken at project planning meetings. The methods used are consistent with other reported research. For example, McAlearney et al. (2004) used focus groups and interviews to investigate the use of PDAs by doctors. Papazafeiropoulou and Gandecha (2007) examined the implementation of a local Health Authority system drawing on data from interviews and meetings.

4. Findings

The presentation of case data is based on illustrated narrative style, or an oral narrative told in the first person, as described by Miles and Huberman (1994) and Myers (1999). This approach as described by Miles and Huberman, 1994 does not resort to explicit coding but looks for “... key words, themes, and sequences to find the most characteristic accounts.” Preliminary findings have been reported in Dawson et al (2005) and Fisher et al, (2006).

4.1 DIAGNOSIS: Understanding existing clinical ICT systems and expectations of mobile wireless technology

Observation of staff and interviews with the Nurse Unit Manager (NUM) and Stroke Liaison Manager (SLM) indicated the following general issues:

Frustration: Many staff were competing for a small number of fixed workstations leading to high frustration levels. There was also a lack of IT infrastructure and support adding to that frustration. The IT budget was under resourced which led to delays in maintenance and update of systems. Access to computers was 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.” (NUM)

However, expectations for continuous improvements especially with a mobile wireless environment were high. Ward staff had become comfortable and confident with the use of computer-based printouts for blood tests and this eased the transition to an electronic order system.

"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]." (NUM)

High need for communication technology: The personnel working on the ward are highly nomadic in a variety of contexts – within the ward, within the hospital and within the wider healthcare regional network. There is extensive use of pagers, phones and fax. Fax is used " ... for photocopying discharge summaries, we fax a lot of things to pharmacy and to the GPs about the people being discharged. Also fax to other departments. The discharge summaries are handwritten and we photocopy it and fax it to the GPs." (Nurse1) Phones are used to talk to relatives of patients and doctors. Doctors who are paged usually respond by telephone.

The proposed mobile wireless infrastructure was expected to provide a reliable communications environment for nomadic clinicians. Additional infrastructure such as smartphones, IP phones, ruggedised PDAs and mobile laptops on purpose-built trolleys were expected to be tested in the ward environment to see whether they delivered the data management and communications needs of the stakeholders.

Lack of integration of paper-based processes and ICT infrastructure: Paper 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. Everyone writes on 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 ... We are obliged to keep it 7 years. It is all paper based. The records are electronic but the diary records are manual."* (NUM)

In this case the recording of patient care activities was done using paper-based systems at the point of care (POC), and the paper-based information was not easily integrated with the fixed ICT systems. This hindered effective data sharing. The formal medical record was maintained electronically, but with some time lag, while current patient notes used for handover and day-to-day management were managed in paper form. Information in the diary should eventually make its way into the electronic record. Also any analysis of data for diagnostic purposes often required a trawling of handwritten notes which made analysis very time consuming. Further, the delivery of test results to the ward in hard copy had led to lost information and duplication of tests such as x-rays and scans.

The NUM and SLM were 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 would assist in increased sharing of data and information between all health professionals on the ward.

The overall expectation is best summed up by the SLM: *"I have a sort of utopic [sic] expectation of the future... we would do a ward round ... 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 deal with that patient ... 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."*

5. IMPLEMENTATION: Implementing a mobile-wireless infrastructure and monitoring use and acceptance

The current mobile wireless implementation has not entirely fulfilled expectations of either the managers or the staff. Some mobile-wireless technologies have been successfully adopted on the ward particularly wireless laptops on trolleys. PDAs and tablet PCs have been less successful. Integration of the technology with existing HISs and training have been major issues. Security of data access is problematic within the hospital's HIS; PDA applications are difficult to source and implement; there are issues with power and batteries, security of equipment and transportability of devices in a hospital ward setting.

The implementation process of the mobile-wireless information environment depends heavily on the support of managers who acted as champions for the introduction of the technology. Several issues became apparent during implementation of the mobile wireless environment.

5.1 Access and security issues

There were two major categories of access which were problematic, difficulty in getting physical access to the equipment and difficulty in getting access to the Internet and hospital information systems through login systems.

5.1.1 Physical access and security

Lack of equipment availability either because of heavy use during the day or because it is locked away at night has discouraged some staff; and they are particularly unenthusiastic if logging in is difficult.

The major security issue relates to the actual devices. One of the laptops on a trolley has already been damaged by a disoriented patient and the nurses raised this as a concern. “... *we have already lost one laptop with a patient hitting it with a walking stick ... [and] ... the day before someone nearly knocked [the laptop] right off [the trolley] going past.*” (Nurse2) Also, physical security risks such as losing a PDA “*Something like that will just be left at the bedside and lost, ... unless you did it like the pagers with the chain on it.*” (Nurse3) There was also concern regarding the device getting wet.

5.1.2 Data access and security

Login times and password are very slow. Security of data access is a constant problem. Because of the slow login/logout process generally nurses rely on one person logging in at the start of a shift and then everyone else using the laptop through that login. However, if a user logs in to a mobile-wireless laptop, uses it and then walks away without logging off, after a short time the hospital's network ‘screen saver’ locks the screen restricting further network access. This leads to frustration as expressed by this nurse: “*If someone opens it on their password and don't close it at the end of the day then the computer goes into like a shutdown and gets locked and you can't open it unless you know the password. ... so you literally have to crash the computer to reopen it. ... If I recognise someone's number (referring to a particular nurse's user number) I have actually rung them at home to find out their password.*” (NUM2)

5.2 Implementation issues in a clinical environment

Clinical staff were generally comfortable with ICT. They all use the computers located at the front desk of the ward and paging system. Many were aware of and had seen the PDA and tablet PC being trialled but few had used them in their day to day work. Ultimately, PDAs have not been universally implemented. The laptops on trolleys were more easily integrated and are mainly used for “... *looking up path results, x-rays and things like that, ... Internet information, MIMS [an international pharmaceutical database] ... to find drugs around the hospital if we don't have any, ... if there is a medical condition the girls [sic] might not have heard of, have a quick look, using Yahoo! or Google.*” (NUM)

However, using the laptop on the trolley to provide data at the POC is not yet standard practice for nurses. “*I actually walk to the trolley instead of taking it anywhere.*” (Nurse2)... and ... “*I think you would have problems with privacy ... [also] ... you get patients who are aggressive. We have had already one of those [laptops] smashed.*” (Nurse 4) and, in most cases, access to data was only occasionally necessary and that it was not worth bringing the computer with them. “*As nurses you just tend to walk. ... when you are looking at blood ... there is no specific time for looking up blood results – it is a one-off thing. There is no purpose in wheeling the trolley into the room if you are only doing random things on it.*” (Nurse 5) Other nurses agreed and said that they tend to leave the trolley parked somewhere but “*For the doctor's round it is really good, they actually take them around to each of the rooms.*” (Nurse 3)

For nursing staff many did not see ICT as integral to their nurse practitioner role. The use of ICT was seen as a separate and often intrusive activity taking them away from their “proper” nursing role. “*Nurses look after people, computers don't look after people. Computers have results; computers can*

show you things that have been done technology-wise. They can look at blood results and that sort of thing but personally nurses look after sick people.” (Nurse 6)

A wireless PDA at the point of care was seen as a potential advantage:

“If you are in charge and someone deteriorates you are the first person to get called so in that respect if you’ve got information in your pocket ... instead of having to run away from the patient who was not breathing, look for a computer see if it is charged, take it back, wait for it to log in ‘Oh my God someone has locked it’, take that away get another computer and come back, ... that [a PDA] would be better.” (Nurse3)

However, the practicality of mobile devices is an issue. PDAs appear to be a useful device for a constantly mobile ward nurse but their usefulness is perceived as limited in practice. The issues that emerged included:

Most nurses felt carrying another device such as a PDA would be a nuisance. “No we would not like it. It is just that when you are leaning over patients all the time you are at risk of it banging against the bedside and then having patients grabbing it, we work with confused patients. A pouch or a holster would be better ... [and] ... It would annoy the hell out of me after a while.” (Nurse 4)

PDA screen size, and poor battery life are also issues. To view an entire pathology result the nurses have to scroll up and down, and left and right. This is cumbersome and time-consuming and reduces the nurses willingness to use and further adapt the PDA for patient use.

5.3 Change management issues

Change management issues became evident in the interviews. Many of the nurses felt disengaged by the implementation approach taken by management. There was concern that not everyone would feel happy and comfortable about the change: “*My concern is that we don’t (shouldn’t) feel like it is being forced on us and that there is a bit of compassion shown to people who are a bit scared about using it – and so you are learning something as opposed to being threatened by something.*” (Nurse 6) Another nurse commented: “*You don’t want to be made to feel silly, you don’t want to feel incompetent - which you can if you don’t train people*” ... and ... “*I have seen so many changes in nursing from where I trained, from where nurses train now, and now technology. ... I just think it is just getting more and more complicated to be just a plain hands-on nurse. Maybe it is just me not accepting major change - I don’t think it is. I think, hell what is going to be the next change?*”. (Nurse 7)

The ward had become a test-bed for new systems and approaches, not just ICT and change on the ward previously has not always been managed well.. One nurse commented: “*We were just told. ‘We are going wireless ... deal with it.’ (Nurse 3) We were told a good while ago, ... it was mentioned and then it was quiet. Then suddenly the patient system happened and then suddenly the laptops are here.*” (Nurse5) ... and ... “*We are not given time for the acceptance of things on this ward, we don’t get time for acceptance*” (Nurse 6) ... and ... “*Sometimes the pace of this ward changes so fast you are trying to deal with it. You try and help each other but that takes you away from other admin duties. It has to be introduced slowly.*” (Nurse 7)

5.4 Training issues

A number of the nurses commented on the lack of training and the time needed to learn and integrate the new system into their daily activities delivering quality patient care.

The hospital does not appear to have readily available technology trainers, training programs or facilities. Most of the training in this case was conducted either ‘on the job’ by other ‘knowledgeable’ ward staff, ad-hoc by outside technical persons visiting the ward, or not at all.

Some more technology aware nurses had self-trained “*I’ve taught myself how to look up scans once I found out what the password was - then I started to play a little bit. Now I realise you can type in a patient’s number and you can get all the scans up and you see what people are booked in for.*” (Nurse 8)

6. Discussion and implications

The introduction of any new technology in a complex environment such as a hospital may not be straightforward as this case illustrates. The enthusiasm and persistence of the NUM and SLM in this case were key factors for success. They were positive and cautiously optimistic about improvements being achievable on their ward by the appropriate application of new ICT and mobile wireless technologies.

Our research found that many of the clinicians acknowledged the usefulness of the devices but there was a high level of scepticism, concern and “resistive compliance”. Technological issues such as developing further applications for the PDAs, solving password and login problems still need to be addressed. Practical aspects of implementation such as how to transport the mobile wireless devices (secure trolleys for laptops, holsters for PDAs etc) need to be trialled and customised based on users’ feedback – in this case the nurses at the bedside. For the work of the ward to be carried out efficiently, these nomadic staff need to be in constant communication with one another. 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. A major issue concerns change management and training which are critical to the acceptance and use of new mobile wireless technologies.

The identification of these issues indicates that the introduction of new ICTs such as mobile wireless technologies in any existing workplace requires a holistic approach based on the following:

- Understanding underlying work practices in the implementation environment is necessary for technology acceptance. Mobile ICT-based activities need to be actively encouraged as an integral part of the clinician’s role;
- Stakeholder analysis and management is necessary in technology adoption projects with large and diverse groups of stakeholders. Emerging technologies such as mobile ICT require new ways of thinking about technology adoption.
- New mobile, wireless ICT environments need to be incrementally integrated with existing ICT – especially in terms of access and security;
- The implementation of mobile wireless environments needs to be based on appropriate change management practices such as consultation, feedback and information dissemination, timetables for introduction, education and training; IT service support and planned incremental HIS integration; and
- There needs to be positive reinforcement such as recruitment of “champions” to lead by example and provide support; and incentives for buy-in buy ward staff;

Further, it was found that the action research methods used in this project provided an appropriate and useful approach for understanding the implementation of emerging technologies in a structured workplace. In particular, it was found that stakeholder analysis should take place early in the project lifecycle to ensure all viewpoints are being considered and that there is a common understanding and agreement of outcomes. In this project the separation of research focussed activities from technical activities and project management activities assisted in creating a constructive implementation environment.

7. Conclusion

This paper has presented the findings from an action research project which analysed the expectations for mobile wireless ICT in a hospital ward setting and monitored the subsequent implementation of a mobile wireless information system infrastructure.

The results indicate the importance of understanding the work practices of clinical and nursing staff in a hospital setting before new technologies are introduced. The findings also indicate that there are many issues across the interface between ICT infrastructure, work practices, and organisational and managerial approaches that need to be addressed when introducing new technology into the workplace including consultative change management and appropriate and timely training. We propose a holistic and incremental approach based on strong foundation research into the work practices that will be supported by new technologies and implementation facilitated by ongoing consultation and education.

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