The wireless operating suite

A review of good practice

A Victorian Government initiative

Victoria The Place To Be

The wireless operating suite

A review of good practice

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Published by the Victorian Government Department of Human Services, Melbourne, Victoria.

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April 2009 (0900401 FM)

Acknowledgments

The Wireless Operating Suite: A review of good practice has been developed by the Australian Centre for Health Innovation for the Department of Human Services. The report was developed in consultation with the Wireless ICT in Surgical Services Steering Committee. The following committee members are to be acknowledged for their contribution:

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Contents

1. Document overview

What is the purpose of this document?

This document has been developed to assist health services in the decision making process for the potential integration/implementation of wireless technology within surgical services.

What does this document contain?

This document contains a review of the literature on good practice in wireless services for surgical services.

What is wireless technology?

A wireless network is any form of computer network that does not require wired connections for information exchange. The most common form today is WiFi, which uses radio waves as the medium for information transmission[1]. Wireless technologies are used for identification and tracking of mobile equipment, staff or patients, cordless voice communications, or data access and data capture by mobile staff or mobile medical devices such as endoscopic capsules.

Why has this document been developed?

Due to the intense, highly technical nature, high cost and time criticality of surgical services, the ability to decrease risk and increase efficiency is paramount. Wireless technology has the potential to enable increased safety, productivity and efficiency gains.

Research has shown health services are beginning to realise the potential benefits of wireless systems to improve the availability of information at the point of care, to find and identify people and equipment, to enhance communication and to support new diagnostic modalities.

Who is this document for and why?

This document is intended for all public hospital health providers in Victoria seeking information regarding wireless ICT innovations for their surgical services.

It is suggested this document is of particular note to the following stakeholders and outlines their potential roles:

Clinicians and business managers need to clearly identify the clinical and administrative problems that would benefit from wireless technology and drive the engagement of their peers in improving the work processes and clinical outcomes.

Health services leaders need to invest in technology and the associated change in processes to support more efficient and effective surgical practice.

Chief Information Officers and their staff need to understand the capabilities of the wireless technology, and its application for surgical services. They should also be aware that there is little evidence to support concerns regarding security and privacy of information and the reliability of wireless technology.

1 Wikipedia, 2008, <www.en.wikipedia.org/wiki/Wireless_network>, accessed 21/11/08

Vendors need to develop wireless systems in partnership with clinicians and health managers to understand their needs and develop wireless systems that are easily adopted and add value to the surgical processes.

Researchers need to undertake further evaluations of health information technology implementations. Evaluations are limited in health today, with most being case study reports. These case studies show there is significant potential for improved patient identification, reduced time taken in documentation, and increased use of clinical guidelines, when wireless technologies are used to support clinical care processes.

2. Background

In January 2009, the Department of Human Services (DHS) engaged the Centre for Health Innovation to develop a review of good practice pertaining to wireless technology in surgical services (peri-operative environment).

The aim of this review was to analyse current research to determine the potential usefulness of wireless technology to Victoria's public hospitals. It is intended that from this research the stakeholder will be able to make an informed decision regarding the potential integration/ implementation of wireless technology within surgical services.

3. Methodology

A search of the literature was conducted using the National Library of Medicine PubMed database to locate relevant literature relating to wireless Information and Communication Technologies (ICT) for surgical services. As the number of studies of wireless technologies in health was low, the search was broadened to include recent reviews of studies on health ICT applications, not specifically mentioning wireless technologies. An online search of the grey literature was also conducted using Google.

The review of the literature identified a number of administrative and clinical areas in which wireless technologies are being utilised in healthcare. These were classified as clinical and administrative categories. Within each of these major categories a number of specific applications were described. These include:

Clinical

- Hand held devices or carts for access to clinical information and data entry.
- Voice Over Internet Protocol (VOIP) communication systems.
- Wireless medical devices such as endoscopic capsules or wireless ECG monitoring.

Administrative

- Patient or equipment tracking.
- Supply chain management.
- VOIP communication systems.

No systematic reviews of wireless technologies in healthcare were found. Most were descriptive case studies, some included pre and post implementation evaluation. Thus this good practice paper has a significant component of inferences that can be drawn from the studies in non-wireless applications, and of case studies available in the grey literature.

4. Health information communication technology

Health care today is a knowledge-intensive industry and requires information sharing and coordination between an increasingly large number of players. This is particularly so in surgical services where a large number of staff are involved in intense, highly technical, high cost, and time critical service delivery. Whilst intuitively information technology has an important role to play in information sharing and coordination, its promise has yet to be fully realised in health. The literature is quite mixed, but includes an increasing number of anecdotal case studies reporting positive outcomes in terms of safety and efficiency of care. Few studies have higher levels of evidence. A key finding of this review was that whilst there is increasing anecdotal evidence for the positive benefits of health information technology (HIT), there is a need for more formal evaluations of the cost benefit both for HIT in general and specifically for wireless technologies.

A systematic review of the scientific literature by Chaudry et al in 2006 showed 257 studies, primarily of health records or decision support systems The findings of this study agreed with those of a review in the same year by the Agency for Healthcare Review and Quality (AHRQ), which concluded that electronic health records (EHRs) had the potential to significantly improve the safety, effectiveness and efficiency of health care. However, as approximately 25 per cent of these studies were from four institutions: the Regenstreif Institute; Partners Health Care (including the Brigham and Women's Hospital); Intermountain Health Care; and, the Veterans Affairs system in the USA[2], both reviews concluded that there was a lack of generalisable knowledge as to how to implement such systems outside those key settings[3]. Each of those health services had undertaken many years of iterative development of their own systems of electronic health records with significant engagement of staff and, as yet, there is no evidence that the implementation of 'off the shelf' EHRs leads to the same improvements in care.

Most of the literature that is available today cites anecdotal case studies rather than quantitative research. In a series of interview-based case studies, Turisco and Rhoads found that there was significant anecdotal evidence that information technology was contributing to improved patient care and job satisfaction amongst nursing staff from innovative hospitals across America[4]. Whilst not identifying a causal link, it is interesting to note that in a recent study carried out in Texas, hospitals with automated notes and records, order entry, and clinical decision support had fewer complications, lower mortality rates, and lower costs[5]. Thus, whilst there is not a significant amount of evidence as yet, the literature shows HIT has the potential to be beneficial.

2 Chaudhry B, Wang J, et al, 2006, *Systematic Review: Impact of Health Information Technology on Quality, Efficiency, and Costs of Medical Care,* Ann Intern Med, 144(10), pp742-752.

3 AHRQ, 2006, *Evidence Report/Technical Assessment Number 132,* Cost and Benefits of Health Information Technology, April 2006.

4 Turisco F, Rhoads J, 2008, *Equipped for Efficiency: Improving nursing care through technology,* California Healthcare Foundation, December 2008, <www.chcf.org/topics/view.cfm?itemID=133816>, accessed 10/2/09.

5 Amarasingham R, et al, 2009, *Clinical Information Technologies and Inpatient Outcomes A Multiple Hospital Study,* Arch Intern Med, 169(2), pp108-114.

An issue that has led to caution amongst health services in the use of HIT is the published evidence of unintended consequences arising from such implementations. For example, whilst medication order entry has been shown to reduce serious medication errors in hospitals by more than 50 per cent[6,7,8], it has also introduced other errors such as an overabundance of inappropriate alerts[9]. Concern is such that in December 2008, the Joint Commission issued a Sentinel event alert for unintended adverse events associated with the implementation of health information technology and converging technologies (medical devices using HIT)[10]. It stated that:

'…The overall safety and effectiveness of technology in health care ultimately depend on its human users, ideally working in close concert with properly designed and installed electronic systems. Any form of technology may adversely affect the quality and safety of care if it is designed or implemented improperly or is misinterpreted. Not only must the technology or device be designed to be safe, it must also be operated safely within a safe workflow process.'

As the National Research Council (2009) reports, many HIT implementations do nothing to support clinical cognitive processes or the workflow of the people who use the systems[11]. As a result, these systems can increase the workload and introduce new forms of unintended errors (Ibid).

These findings suggest that whilst information technologies have significant potential to improve the administration and patient care in surgical services, care needs to be taken to ensure that the solution implemented adds value to the clinicians or administrators that they are intended to support. To reduce the risk of unintended consequences for patients and staff, the end users should be engaged throughout any HIT project to clearly articulate the processes that the technology is intended to support, and the anticipated benefits, risks and constraints. Realistic modeling of the work practice using the new technology is a well accepted risk mitigation approach, prior to production implementation in the health setting.

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6 Bates DW, Leape LL, et al, 1998, *Effect of Computerized Physician Order Entry and a Team Intervention on Prevention of Serious Medication Errors,* JAMA, 280(15), pp1311-1316.

7 Ammenwerth E, Schnell-Inderst P, et al, 2008, *The Effect of Electronic Prescribing on Medication Errors and Adverse Drug Events: A Systematic Review,* J Am Med Inform Assoc, M2667.

8 Koppel R, Metlay JP, et al, 2005, *Role of Computerized Physician Order Entry Systems in Facilitating Medication Errors,* JAMA 293(10), pp1197-1203.

9 Campbell EM, Sittig DF, Ash JS, et al, 2006, *Types of Unintended Consequences Related to Computerized Provider Order Entry,* Journal of the American Medical Informatics Association, Sep/Oct 2006, 13(5), p547.

10 Joint Commission, 2008, *Safely implementing health information and converging technologies,* Sentinel Event Alert Issue 42,11/12/08.

11 National Research Council, 2009, *Computational Technology for Effective Health Care: Immediate Steps and Strategic Directions,* Stead WW, Lin HS (Ed), National Academic Press.

5. Wireless technology

5.1 What is wireless technology?

Wireless technologies are the means by which digital information is transferred over a distance without the use of electrical conductors or 'wires'. These technologies include radio wave, microwave, infrared, and laser technologies. In health services today, the most common systems used are radiofrequency (RF) systems. To read the RF signals, a wireless local area network (WLAN) is established using RF receivers strategically located around the building. RF signals within the range of those receivers can then be read and transmitted by wires back to the main servers and applications.

Wireless technologies are robust and in everyday use in many industries. Whilst health is a relatively late adopter of such technology, experience at the Centre for Health Innovation is that many Australian health services, and each of the major greenfield hospital developments in Australia, are incorporating enterprisewide wireless information systems into their planning.

In the UK and USA, early technology adopters such as Birmingham Heartlands Hospital[12], Brigham and Women's Hospital[13] and El Camino Hospital[14] have been involved with wireless technologies for several years and are now implementing pervasive, organisationwide, rather than isolated wireless access, to ensure consistency of access across the health service.

5.2 When is wireless technology useful?

Wireless technology is not a solution in itself. It is an enabler and should be implemented in response to a clinical or administrative problem. In order to decide whether wireless technology is required, the business processes should first be clearly defined by the clinicians and business managers. Next, the applications required to support the process and the most appropriate method of accessing the solution should be agreed upon.

There are three common business drivers for introducing wireless technologies. Firstly, and most commonly, they provide a means of transmitting data that allows more **flexibility for a mobile staff member requiring information access, data recording, or two-way communication**, secondly they can provide the **ability to track items in real time** and lastly they can provide information transmission **where physical wiring and cabling is not feasible, or appropriate.**

Each of these business drivers is valid in itself, and intuitively it makes sense that wireless systems can enhance patient care and health system efficiency. However, there are many factors other than the technology itself, that contribute to the outcomes of an HIT project.

12 *Safe Surgical Systems,* Heartlands Hospital, <www.heartofengland.nhs.uk/templates/Page____6953.aspx>, accessed 23/1/09.

13 Bachelder B, 2008, *Brigham and Women's Hospital becomes totally RTLS-enabled,* RFID Journal 20/2/08, <www.rfidjournal.com/article/articleprint/3931/-1/1>, accessed 24/1/09.

14 *Wi-Fi comes to El Camino Hospital,* 7/8/08, ABC7 News, San Francisco, <www.abclocal.go.com/kgo/story?section=news/local&id=6313656>, accessed 23/1/09

5.3 Factors influencing health ICT project outcomes

As with other ICT projects in health, key prerequisites for successful wireless implementations include:

- Clear business drivers and functional specifications have been defined by the users.
- The current or proposed workflow is clearly understood.
- A sound business case, including a clearly identified benefit for the use of wireless rather than fixed cabling.
- The organisation is committed and ready to manage the work practice changes.
- The risks involved have been considered and accepted or managed.
- The workflow can be tested using the new technology before it goes live.
- Staff are appropriately trained to both administer and use the new technology.

Clinicians, CIOs, managers and funders each have key roles to play in ensuring that surgical service productivity, and clinical care are supported effectively by wireless technologies. Examples of the significant impacts that can occur when wireless technologies are effectively implemented in response to business imperatives, are given in the next section.

Clinicians, Chief Information Officers, managers and funders each have key roles to play in ensuring that surgical service productivity and clinical care are supported effectively by wireless technologies. The next section provides examples of the significant impacts that can occur when wireless technologies are effectively implemented in response to business imperatives.

6. Application of wireless technologies in surgical services

Clinical applications

6.1 Mobile devices for access to clinical information and data entry

Both the grey and white literature show that clinical staff are using wireless systems to access clinical information and to enter data. The business drivers are frequently stated as enhanced patient safety or quality of care and workforce productivity.

Wireless systems for clinical information system access range from small devices, such as phones and Personal Digital Assistants (PDA), to tablets and computers/workstations on wheels (WoW). Whilst there are not many studies of the impact of wireless access to clinical information systems, what is available suggests that it may positively impact both on the time taken to access or enter information and the number of times that clinical guidelines are accessed by staff, provided the right devices are used for the task.

Bullard et al (2004) carried out a randomised controlled trial of wireless laptop computers on a wheeled stand in an emergency department. They found that the mobile computer significantly increased the use of clinical practice guidelines and decision support tools, however major limitations recognised by the study were the space limitations at the bedside in an emergency department and the inconvenience of moving the mobile computer around for a whole shift[15]. The workstation on wheels used in this study were heavy full desktop computers, which were difficult to manoeuvre.

In a recent study at Robina Hospital on the Gold Coast, the introduction of wireless tablet computers to access clinical information systems resulted in 75 per cent of medical staff saving 15-45 minutes per day in accessing images and ward round results and a 30 per cent time saving in updating patient notes[16]. This study also supported the finding by Bullard et al (Op cit) that providing wireless access increased the use of clinical practice guidelines by clinicians.

Mobility can also involve mobile phone communication. In a study by Perez et al (2006) patients sent pictures and pulse oximetry readings by mobile phone after discharge from day surgery. In 18 per cent of the 49 patients studied, the transmission of images resulted in their treatment being modified and eight avoided a visit to the emergency department[17].

6.2 Patient and product identification

Patient identification is recognised by Australian and other world health authorities as a key safety issue. Patient auto identification is the use of machine-readable barcodes or Radio Frequency IDentification (RFID) tags on patient wrist bands to assist in the positive identification of patients. RFID can involve small **passive tags** in the wrist band, or larger, for example matchbox size, **active tags**. Both tags can store electronic data but passive tags need to be excited by a local reading device to transmit their data. Active tags have their own batteries inside and 'chirp' out data at predetermined intervals. Active tags can be tracked in real time by triangulating their location from the wireless access points that pick up their signals.

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15 Bullard MJ, Meurer DP, et al, 2004, *Supporting Clinical Practice at the Bedside Using Wireless Technology,* Academic Emergency Medicine, 11(11), pp1186-1192.

16 NTF, 2008, Project Fido executive report, *Evaluation of the implementation of mobile computing in the AMU at Robins Hospital,* Queensland Government, October 2008.

17 Perez F, et al, 2006, *Evaluation of a mobile health system for supporting postoperative patients following day surgery.* Journal of Telemedicine and Telecare, 12(1), pp41-3. Retrieved 13/1/09, from ProQuest Health and Medical Complete database. (Document ID: 1138134371).

Passive tags are for local data scanning, or can be read by a choke point at a doorway or other confined area such as a checkout in a supermarket. More recent developments include the incorporation of passive RFID readers into smart document trays[18] for the tracking of stacked documents.

The Department of Health in the UK has published a Best practice guideline on patient identification, entitled Coding for Safety: simple technology for safer patient care[19]. Available online, this paper is a useful resource for surgical services investigating technologies to improve patient identification. Whilst not discussing the potential for wireless systems per se, the paper does give a good overview of applications and evidence for the use of barcoding and other coding technologies such as RFID, in patient care. The paper concludes that there is a compelling patient safety case for the use of coding systems to match patients to their care. They also note that there is significant work still to be done to ensure standardised coding on manufactured products and on patient wristbands.

The lack of standards and application of RFID, and to a lesser extent barcode technology, means that, for example, surgical patients could be identified and tracked with active tags to follow their progress through a theatre suite. However this system could not be used for medication dispensing as medications are not currently tagged with RFID, nor are they often labelled at the unit-dose level. Scanning medication for a patient would require a barcode scan of the medication package. Good practice in the use of auto identification technology for both business processes would require both barcode readers and RFID technologies.

The Australian Commission for Safety and Quality in Healthcare published a review entitled Technology Solutions to Patient Identification, in October 2008[20]. This review gives three examples of barcode systems for patient ID, but does not mention wireless systems or give any examples of RFID technology in Australia. Case studies of RFID systems used for patient identification and tracking include surgical patient management at Birmingham Heartlands Hospital (UK), and patient tracking at Oakwood Hospital (USA) and St Mary's Hospital (South Korea).

At Birmingham Heartlands Hospital, patients are given a wristband containing a passive RFID tag on admission. They also have a digital photograph taken and this is filed in their electronic patient record (EPR). Whenever a patient's electronic record is accessed, the patients photograph is displayed to assist in identification. In surgery, the RFID tag in their wristband initiates the display of the relevant patient record on the theatre computer screen and is also used to generate a pre-printed UR label, if a biopsy is taken during surgery.

The British Department of Health reports that Heartlands Hospital system saves an estimated £270,000 per year[21] but unfortunately there is insufficient detail published to understand how this figure was derived, or if it was substantiated in subsequent years.

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18 NEC, 2006, *RFID Document tracking system data sheet* <www.nec.com.au/docs/nec_rfid_document_tracking_system.pdf>, accessed 15/1/09.

19 Department of Health, 2007, *Coding for Success: simple technology for safer patient care,* <www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyandGuidance/DH_066082> accessed 24/1/09.

20 ACSQHC, 2008, Report of review, *Australian Council for Safety and Quality in Health Care,* October 2008, <www.safetyandquality.gov.au/internet/safety/publishing.nsf/Content/CE1F60BEAF285FF7CA2574E400219A9F/$File/19794-TechnologyReview.PDF>, accessed 5/1/09.

21 Department of Health, 2007, Op cit.

At Oakwood Hospital in Michigan, RFID tags are being introduced for active patient tracking across the hospital after a successful pilot of 64 patients through 14 departments over two floors[22]. A similar system is in use at St Mary's Hospital in South Korea. No outcomes of these implementations appear to have been published.

It is beyond the scope of this review to examine barcode technology for patient identification. However, for those interested, a good review of this technology has recently been published by the Agency for Healthcare Research and Quality in the USA[23].

6.3 Wireless medical devices

Wireless medical devices range from wireless data transmission for existing medical devices, such as cardiac monitors, to entirely new developments that are possible because of wireless technology, such as endoscopic capsules. It is likely that the increasing implementation of wireless systems will increase the number of new developments.

The use of wireless medical devices has opened up a new field of wireless monitoring, which allows continuous, live monitoring of ambulant or bed fast patients. In a pre and post comparison, Kisner et al (2008) showed that continuous wireless monitoring for post op patients on the ward reduced the incidence of atrial fibrillation after cardiac surgery from 26 per cent to 14 per cent ($p = 0.016$). The monitor generated alerts based on preset thresholds. Oxygen therapy was instigated if O^2 saturation dropped below 90 per cent[24].

Mattress pad sensing devices can now be used on existing beds to monitor heart and respiratory rates. The mattress coverlet also includes pressure sensors that can send an alert when a patient attempts to get out of bed. A study at the James A Harley Veterans Administration Hospital in the USA is reported to have found that the use of wireless monitoring of heart rate and respiration meant that 12 per cent patients received more timely changes in care than they would have had if continuous monitoring had not been in place[25].

Medical devices require medical grade wireless networks with sufficient backup systems to ensure the confidentiality, integrity, availability and safety of the data generated and transmitted by the device. International standards for wireless medical devices and the wireless systems that support them are under development at present[26]. It is thus particularly important that both hospital IT departments and biomedical engineering staff are engaged in the design, purchasing and ongoing support of the WLAN and the medical device concerned.

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22 Ibid.

23 Hook J, et al, *Using Barcode Medication Administration to Improve Quality and Safety: Findings from the AHRQ Health IT Portfolio,* (Prepared by the AHRQ National Resource Center for Health IT under Contract No. 290-04-0016), AHRQ Publication No. 09-0023-EF, Rockville, MD: Agency for Healthcare Research and Quality, December 2008.

24 Kisner D, Wilhelm MJ, et al, 2009, *Reduced incidence of atrial fibrillation after cardiac surgery by continuous wireless monitoring of oxygen saturation on the normal ward and resultant oxygen therapy for hypoxia,* European Journal of Cardio-Thoracic Surgery, 35(1), pp111-115.

25 Turisco F, Rhoads J, 2008, Op cit.

26 <www.medicalconnectivity.com/2008/05/26/iec-80001-an-introduction>, accessed 6/2/09.

6.4 Communication

Voice Over Internet Protocol (VOIP) is the means by which voice messages are now most commonly transmitted. It involves routing the communication over computer networks. The development of VOIP allows the wireless system used for patient tracking or clinical information system access to be used for WiFi cordless phones. This convergence of wireless network use saves duplication and maintenance costs.

As well as replacing cordless phone technology, VOIP systems are also being used for:

- Two-way rather than one-way paging, so that the sender knows if a page is received and or acknowledged
- Hands-free communication
- Role-based communication - so that staff can be located by role rather than just by name. This reduces the time taken to find out who is on what roster at any particular time

Communication is an under-recognised area for significant improvement in surgical services. Wireless communication technology is robust and well adopted in our communities, however most hospitals still use the one-way pager systems that have been in use for over 20 years. With this traditional paging, the sender does not know if the page has been received or acted on unless they receive a return phone call. It is not uncommon for paging 'ping pong' to occur, wasting time for those involved.

Synchronous two-way communications are important in current perioperative and anaesthetic practice. Whilst the following studies were not all carried out in a perioperative environment, they are presented here as the communication issues for anaesthetic and surgical clinicians are similar to those in other acute settings.

At Vanderbuilt University Medical Centre, a 2006 study showed that staff responded to communication queries four times faster with VOIP phones than with conventional pager-telephone systems[27]. The researchers concluded that the technology could be used securely and efficiently. They also recognised that lack of full wireless coverage, speech recognition difficulties and concern with privacy during communication (using speakerphone devices) were significant problems in the implementation of this technology.

At Sampson Medical Centre in Clinton, North Carolina, WiFi telephones are used extensively. For example, critical pathology results are sent to the treating doctor and nurse. Each must acknowledge receipt of the message within five minutes or the messages are escalated to the charge nurse, nurse supervisor and back to the lab[28].

A survey of the practice of 4,018 anaesthesiologists in the USA, found that those using two-way communication devices (mobile phones) rather than one-way communication devices (pagers) reported significantly lower incidence of communication delays in the critical care environment[29]. A descriptive review from Yale University School of Medicine also concluded that simple devices like cellular telephones and wireless networks were simple cost effective ways to improve communication for patient care[30].

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27 St Jacques P, France DJ, et al, 2006, *Evaluation of a hands-free wireless communication device in the perioperative environment,* Telemedicine and e-Health, 12(1), pp42-49, accessed 24/1/09 at <www.liebertonline.com/doi/abs/10.1089/tmj.2006.12.42>

28 Turisco F, Rhoads J, 2008, Op cit,

29 Soto RG, Chu LK, Goldman JM, et al, *Communication in critical care environments: mobile telephones improve patient care,* Anesth Analg, 2006, 102, pp534-541.

30 Ruskin KJ, 2006, *Communication devices in the operating room,* Curr Opin Anaesthesiol, 19(6), pp655-659.

Hands-free communication devices such as Vocera®, are communication badges that can be worn under a gown and verbally prompt users to respond to an incoming call from the named caller. They can choose to take the call or have it sent to voicemail or email. The ability to triage incoming calls allows an anaesthetist to take a call from a nurse in Recovery, but to send a less urgent outside call to voicemail without needing their hands at all. The same device requires a simple, single button press to initiate a call, which can also be done through a gown. Several hospitals in Australia and other countries are using these systems. A 2004 National Horizon Scanning report notes that a pilot implementation of Vocera in the emergency department at Blacktown hospital in NSW showed a saving of between 260 and 783 minutes per day[31] in a department with eight doctors and 10 nurses on duty at any particular time.

An interesting and reportedly successful use of mobile phones in surgical services, is the transmission of images to assist follow up post day surgery (Perez et al 2006)[32]. In this study, health professionals were able to see images of wounds and dressings sent by patients. The availability of the images resulted in modifications to treatment in 18 per cent of the 49 patients who used the system. It was estimated that a visit to the emergency department was avoided in eight cases.

It is hoped that the software developed to utilise VOIP technology will ultimately lead to voice-activated completion of electronic patient records, however, the technology for this is still some years away. In the meantime, the case studies cited show that robust wireless technologies, such as the mobile or WiFi phones, can add value for communications in the perioperative setting.

31 DOHA, 2004, National Horizon Scanning Unit, *Horizon scanning prioritising summary,* 7(1), Vocera Wireless Communication, October 2004.

32 Perez F, et al, 2006, *Evaluation of a mobile health system for supporting postoperative patients following day surgery,* Journal of Telemedicine and Telecare, 12(1), pp41-3. Retrieved 13/1/09, from ProQuest Health and Medical Complete database. (Document ID: 1138134371).

Administrative applications

6.5 Patient tracking

Tracking of patient flow in the perioperative environment appears to be mainly at pilot or research stage in the literature. Several studies have shown that it is possible to track patients through a surgical episode[33,34]. In 2006, Marjamaa et al compared the accuracy of automatically documented timestamps compared to manual recording of patient flow in the operating theatre. They found that the delay between the activity and documentation of the timestamp reduced from 735s to 80s with an automated system[35]. The study also reported an improved patient flow, although no data was reported to substantiate this.

Surgeons from Birmingham Heartlands Hospital were instrumental in developing and implementing a WiFi tracking system for their Ear, Nose and Throat operating theatres and a day care ward. A report on the Safe Patient Systems™ company website states that throughput was increased by 12 per cent and that four potential errors were avoided since the system was implemented in 2007[36]. The Department of Health report *Coding for Success: Simple technologies for safer patient care* states that cost savings from the Birmingham Heartlands patient tracking program are estimated to be £270,000 per year[37].

A review of patient tracking applications in Californian emergency departments found that of the 51 hospital surveyed, 35 had an electronic emergency department tracking system. Reported results included improved patient throughput and improved documentation[38], although no specific outcome data was quoted. Staff satisfaction with the systems was quite variable; 69 per cent of sites with an electronic patient tracking system said that their implementation could have been better with improved integration, training, more research and testing prior to roll out and customisation for their own processes.

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33 Meyer M, Seim A, et al, 2008, *Automatic Time-Motion Study of a Multistep Preoperative Process. Anesthesiology,* 108 (6), pp1109-1116.

34 Marjamaa RA, Torkki PMM, et al, 2006, *Time Accuracy of a Radio Frequency Identification Patient Tracking System for Recording Operating Room Timestamps,* Anesthesia & Analgesia, 102(4), pp1183-1186.

35 Ibid.

36 Birmingham Heartlands case study <www.safepatientsystems.com/products/safesurgerysystem/casestudy.ashx>, accessed 24/1/09.

37 Department of Health, 2007, *Coding for Success: simple technology for safer patient care,* <www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyandGuidance/DH_066082>, accessed 24/1/09.

38 CHCF, 2008, *Adoption of patient tracking systems among hospital emergency rooms in California,* California Healthcare Foundation, July 2008. <www.chcf.org/documents/hospitals/AdoptionOfPatientTrackingSystems.pdf>, accessed 10/2/09.

6.6 Equipment tracking

A study of wireless location of high value assets at St Vincent's Hospital Sydney[39] found that whilst the technology for locating the assets worked, there was a gap between the task it was designed to support and the requirements of the workflow. In reality, it was difficult for the orderlies and nurses looking for the equipment to access computers, go into the appropriate program, locate the equipment and then find it on the floor. Thus, the uptake of the technology was poor.

Brigham and Women's hospital in Boston has solved this workflow problem by providing nursing staff phone access to Unit clerks and biomedical department staff who look up the location of the equipment for them[40].

A simple functional solution has been developed at the Centre for Health Innovation, which has demonstrated that the addition of commonly used speech recognition software and VOIP can provide staff with direct WiFi phone access to location services. In order to find a piece of equipment, the staff member now presses a speed dial on their phone and asks for the location of a specific tagged asset, for example 'find me the bladder scanner'. The automated service will then respond with, 'The nearest bladder scanner is...' Because both the wireless phone and the bladder scanner are tracked, the system can locate the assets being requested in order of their proximity to the phone being used[41].

Having defined a business problem and identified the optimal workflow, it is worth looking not only at what peer hospitals are doing, but also seeking expert advice on the options available with the use of ICT. The integration of existing technologies such as that described above can contribute significantly to the optimal matching of a technology solution to the desired workflow.

6.7 Supply chain management

Supply chain management in perioperative settings includes inventory control and vendor management. At the Alfred Hospital in Melbourne, the use of H-Trak software in the diagnostic imaging department has reduced the time taken for consumable management/reordering from four days to less than one hour per week[42].

6.8 Communication

Two way and role based communication are important for administrative as well as clinical functions. Finding the After Hours Manager, an Orderly or the Anaesthetic Registrar without having to look up a roster, can save time in a busy department. Workflow management systems include real time bed status monitoring, which can significantly reduce time taken managing beds. An electronic bed status scoreboard at Oakwood Hospital in Detroit, is reported to have reduced the number of patients waiting longer than 4 hours in the emergency department by 50 per cent. Bed assignments within 30 minutes jumped from 52 per cent to 72 per cent, and daily bed meetings were eliminated, giving nurses more time for patient care[43].

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39 Personal Communication, 2007, Chief Information Officer, St Vincents Hospital, Sydney.
40 Turisco F, Rhoads J, 2008, Op cit.
41 Centre for Health Innovation, 2008, Demonstration of integration of CISCO location services, wireless phones, Nuance speech recognition system and PANGO location service.
42 Personal communication, 2008, Alfred Hospital Diagnostic Imaging Department. Melbourne.
43 Turisco F, Rhoads J, 2008, Op cit.

7. Planning for wireless technologies in surgical services

7.1 Wireless technologies

Wireless networks in hospitals primarily use radiofrequency signals. These networks are commonly called WiFi or Wireless LAN (WLAN). The use of infrared light and Bluetooth are also described occasionally in the literature. However, there is insufficient literature available on these latter two technologies to include them in the current literature review.

Wireless LANs have to be designed to suit the specific physical environments of each part of the hospital. Infrastructure has a significant impact on the coverage of a wireless LAN, particularly when there are lead lined walls in procedural areas. Moreover, common workplace items, such as cordless telephones, microwaves, lifts and even fluorescent lights, emit radiofrequency signals that can compete in the wireless spectrum and reduce zones of coverage and quality of service.

In order to successfully implement a wireless system that consistently meets their needs, health services need to engage their Information technology (IT) and/or Biomedical engineering (BME) departments at an early stage in the project. Most commonly, responsibility for wireless networks lies with the IT department, and this will be assumed for simplicity in the following discussions. The responsible group will need to determine how the wireless coverage is going to be planned and managed to ensure continuous, secure services within their area. They will also have to consider how the system in their area will be able to relate, or interact with, systems across the enterprise.

7.2 Design of wireless services

As wireless systems are increasingly deployed, it is important that ubiquitous wireless local area network (WLAN) infrastructure is implemented to support the range of disparate medical devices and voice and data requirements of the health service. It is less cost efficient, and sustainable, to implement separate vendor specific systems for each device or application. However, many health services will find that they have existing wireless infrastructure in some parts of their organisation. These may be specific to voice or computer coverage but may not be able to be used for other applications such as patient or asset tracking. There will then be a need for their IT department to determine the roadmap to develop an enterprisewide system or systems to meet the needs of their health service.

Wireless networks may be deployed in a single department or across a campus. If a local deployment is contemplated, planning for integration with other existing systems should be undertaken, so that staff have continuity of coverage and consistency of infrastructure to both maintain and to use. The health services' IT department will need to develop a plan that will manage not only existing systems and coverage issues, but to be ready for advances and new requirements in the foreseeable future.

It is not uncommon for administrators and clinicians to express concerns regarding the security, safety, privacy and reliability of wireless technology[44]. However, as discussed in the next section, there is little evidence to substantiate these concerns.

44 Gururajan R, Moloney C, Soar J, 2005, *Challenges for implementing wireless handheld technology in health care: views from selected Queensland Nurses,* Journal of Telemedicine and Telecare, 11(2), pp37–38.

7.3 Interference

IT and Biomedical engineering departments will need to work together to ensure that there is no interference from medical devices, phones or other radiofrequency (RF) items. They will also have to ensure that the wireless system that is being introduced does not interfere with existing medical equipment or new medical equipment purchased in the future[45].

There is potential for electromagnetic interference from RFID systems with medical devices such as pumps, pacemakers, ventilators and anaesthetic machines[46]. It should be noted that the radiofrequencies used in this study were European standards at 125KHz and 868kHz, whereas the frequency ranges in the medical band currently used in Australia are much higher at 2.45GHz and 5.7GHz[47]. A review of the safety of wireless technologies by the CSIRO in 2006[48] found that wireless technologies were suitable for use throughout hospital areas, including intensive care units and operating rooms, provided recommended separation from medical equipment occurred. They also found that two-way radios and walkie talkies used by security personnel should be kept six to eight metres away; GSM1800 and CDMA phones 0.5 metre; and wireless LANS/Bluetooth one metre away from medical equipment.

Current legislation regarding RFID can be found on the ComLaw website.[49]

7.4 Security

Unsecured wireless networks, such as when a staff member adds a wireless access point to their hospital computer, should be avoided in health. Once an unsecured wireless network (WLAN) is introduced, any WiFi device such as a laptop or phone can put the hospital network at risk. The ITS department will be involved in designing a secure wireless network that will need to know the unique addresses of the health service's authorised computers and other WiFi devices. Only those devices will work on the hospital network in order to maintain the security of patient records and other hospital systems. Assuming that there are no 'rogue' WLANS, the most important part of security with wireless networks, as with other IT systems, is the use of unique logins and passwords.

45 Van der Togt R, et al, 2008, *Electromagnetic Interference From Radio Frequency Identification Inducing Potentially Hazardous Incidents in Critical Care Medical Equipment,* JAMA, 299(24), pp2884-2890.

46 Van der Togt R, et al, 2008, Op cit.

47 Whitehouse I, 2006, *E-learning using radiofrequency identification (RFID) device scoping study,* Australian Government Department of Education, Science and Training, November 2006. <www.industry.flexiblelearning.net.au/2006/rfid_scoping_study_8dec06.pdf>, accessed 15/1/09.

48 Boyle J, 2006, *Wireless technologies and patient safety in hospitals,* Telemed J E Health, 12(3), pp373-82.

49 <www.comlaw.gov.au/ComLaw/Legislation/LegislativeInstrument1.nsf/all/whatsnew/B206CC850F7947 86CA25753700036CD2?OpenDocument>

7.5 Safety

The World Health Organisation published a report in 2006 stating that 'no adverse short term or long term health effects have been found to occur from the RF signals produced by base stations. Since wireless networks produce generally lower RF signals than base stations, no adverse effects are expected from exposure to them'[50].

7.6 Wireless devices

Care needs to be taken when selecting mobile devices to ensure that they meet the needs of the user and the organisation. Considerations include:

- Battery life - does it need to last a whole shift?
- Screen size/real estate - large enough to show a Picture Archiving and Communication System (PACS) image?
- Weight.
- Ease of use.
- Is there a need for a key board to enter notes?
- Is there a need for the device to be hands free?
- Manoeuvrability, if wheeled.
- Space restrictions.
- Ergonomics for viewing the screen and using the input devices.
- Convergence - does the device need to support several applications so that the user doesn't have to carry more than one device?
- Infection control.
- Maintenance and support.

For example, a transfusion nurse takes a trolley around with her to carry samples and thus she could use a device up to the size of a laptop. For a ward round, data entry and viewing of images may be required, so a lightweight workstation on wheels or a tablet computer may suit the requirements best. On the other hand, a nurse or doctor needing their hands free for patient care may use a smaller form factor such as a PDA, provided the required application can be effectively used on that sized screen. In many settings, a variety of devices are required.

The best way to mitigate risk when purchasing mobile devices is to run simulated clinical and administrative processes using a range of devices to evaluate which ones best suit the health service's needs. This reduces the risk of adverse consequences for patients, and of stress on staff when going live in the hospital setting.

50 WHO, 2006, *Electromagnetic fields and public health. Base stations and wireless technologies,* World Health Organisation Fact Sheet no 304, May 2006.

8. Economics of health information technology systems

Health Information technology (HIT) has great potential to improve the quality, efficiency and safety of patient care. However, the complex health environment and the changes involved in workflow and the culture of an organisation make the implementations complex and difficult to evaluate[51]. Even when studies are carried out, they are frequently internal documents that are not available in the public domain.

Several major reviews of HIT have found that there is limited but increasing evidence of improved cost and quality of care in institutions that have developed and been early adopters of HIT[52,53]. However, these studies are from institutions directly involved in the development of the technology. There are almost no studies of the impact of 'off the shelf' technologies. Where these do exist, they are in the form of papers written and owned by the technology companies themselves. The independence of the evaluations is unclear and they are not available for public scrutiny. The business case for health services wishing to implement such technologies is often not available in the public domain. Hence there is a strong need for independent, published evaluations of HIT implementations to enable better business case development for agencies looking to adopt the technology.

51 AHRQ (2006) *Evidence Report/Technical Assessment Number 132. Cost and Benefits of Health Information Technology.* April 2006

52 AHRQ (2006) ibid

53 Chaudhry B, Wang J, Wu S et al (2006) *Systematic review: Impact of health information technology on quality, efficiency, and costs of medical care.* Annals of Internal Medicine 144:E-12-E-22

9. Barriers to use of Wireless Technologies

Implementing wireless systems requires significant changes for staff, both for the direct users and for the support staff. In order to achieve successful implementation of wireless systems, potential barriers have to be identified and addressed. Barriers to wireless technologies in healthcare may include[54,55,56]:

- culture and workflows
- existing problems
- work schedules
- confidentiality
- time for training
- technology expertise
- reliance on technology
- perceived benefits, for example if technology increases the time taken for work
- change management.

Technology issues

- useability
- reliability
- inadequate testing
- security concerns
- coverage of wireless links
- system migration
- technical support
- poor technical implementation

Cost and sustainability

- funding
- ongoing support
- resource requirements, including staff

This inventory of potential barriers to implementation is useful as a checklist to ensure that the team involved in planning and implementing the HIT project has considered, and where necessary developed plans to mitigate these risks. For example, change management associated with technology implementation has been estimated to be up to 80 per cent (Zafar 2005)[57] of the effort required for success in meeting the project's goals. Adequate time and leadership are needed to ensure that the staff understand the changes and the reasons for those changes, and have sufficient training for the new processes to be implemented. Arrangements also need to be put in place for information technology support to be higher initially, so that any queries or technical problems can be quickly overcome.

54 Gururajan R, Moloney C, et al, 2005, Op cit.

55 Gururajan R, M. Quaddus, et al, 2008, *Clinical usefulness of handheld wireless technology in healthcare: a cross-national study of Australia and India,* Journal of Systems and Information Technology, 10 (1), pp72-85.

56 Bullard MJ, Meurer DP, et al, 2004, *Supporting Clinical Practice at the Bedside Using Wireless Technology,* Academic Emergency Medicine, 11(11), pp1186-1192.

57 Zafar A, 2005, *Getting started with Health IT implementation,* AHRQ National Resource Centre for Health Information technology, <www.healthit.ahrq.gov/portal/server.pt/gateway/PTARGS_0_1248_74907_0_0_18/Health%20IT%20Implementation.ppt>, accessed 17/11/08.

10. Useful resources

Studies of health information technology can be found at the AHRQ Health Information Technology database <www.healthit.ahrq.gov/portal/server.pt?open=512&objID=650&PageID=0&parentname=ObjMgr&parentid=106&mode=2&dummy=t>

A series of papers that deal with project management and other aspects of IT implementation can be found in the AHRQ Health IT Adoption Toolbox
<www.healthit.ahrq.gov/toolbox>

The Australian Centre for Health Innovation
<www.healthinnovation.com.au>

Statewide Surgical Services Program, Department of Human Services
<www.health.vic.gov.au/surgery/index.htm>

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