COMMENTARY

RFID Technology in Health Environment Opportunities and Challenges for Modern Cancer Care

Reza Safdari[1], Elham Maserat[1]*, Elnaz Maserat[2]

Abstract

Cancers are significant contributors to the mortality and health care expenditures. Cancer can be reduced and monitored by new information technology. Radio frequency identification or RFID is a wireless identification technology. The use of this technology can be employed for identifying and tracking clinical staff, patients, supplies, medications and equipments. RFID can trace and manage chemotherapy drugs. There are different types of RFID. Implantable RFID allowing a chip to be embedded under the skin and that store the cancer patient's identifier. These are concerns about applications of RFID. Privacy, security and legal issues are key problems. This paper describes capabilities, benefits and confidentiality aspects in radio frequency identification systems and solutions for overcoming challenges.

Keywords: RFID - wireless technology - modern cancer care - identification technology

Asian Pacific J Cancer Prev, **13 (12)**, 6533-6537

Introduction

Cancer is one of the most common chronic diseases that about 99,000 cases are annually occurring (Kim et al., 2007). Modern cancer care is characterized by three important facets: state-of-the-art clinical medicine, which may include evidence-based and sophisticated therapies targeted to patients' tumor and biological characteristics. Second, an approach to care that is attentive to the spectrum of patients' needs (i.e., physical, psychosocial, functional, spiritual). Third, the use of systems solutions, both human and machine, that support organizations in achieving their clinical medicine and patient-centered care delivery goals (IOM, 2001).

Information technology enhances communication, coordination, and quality of cancer care (Clauser et al., 2011) and is rapidly advancing and making its way into many primary care settings. Information technology to enhance delivery of preventive services (Garg et al., 2005; Kawamoto et al., 2005). Systems that automatically prompt users, provide specific recommendations rather than assessments, and provide support at the time of decision making are most successful. A longitudinal, qualitative study of decision support also provides further confirmation of these principles (Rousseau et al., 2003). when a patient whose provider suspects cancer orders a diagnostic PET scan; the resulting digital image is captured, annotated, stored, and shared with a provider in a different location for a second opinion, vastly improving the efficiency, effectiveness, and timeliness of cancer care (Steven et al., 2011).

Wireless communication is easier and cheaper to introduce and to maintain, especially in remote and less developed areas (Matthias et al., 1997). Radio frequency identification or RFID is a wireless tool for identification and exchanging of data by radio waves (Kharif, 2004; Utrecht, 2007). This automatic identification method that allows storing and remotely retrieving data (Government communication office, 2007). RFID can be used to monitor and trace of anticancer drug (Kim et al., 2007). Application of radio frequency identification in health care organizations decreases costs and traces patients, clinical staff, supplies, equipment and medication.

Radio Frequency Identification Types

There are different types of tags (Utrecht, 2007). Different classes is based mostly on the capacity to write data to a tag (University of California, 2007; Utrecht, 2007) and whether or not the tag active (ChiaCheng et al., 2004; Prakash, 2007). Active tags have a battery with a life of several years, a range of tens of meters and a larger data capacity than passive tags. Passive tags use reader emissions to power a brief response, usually just an ID number. They have a short range—about 10 mm to 5 meters—and they can be small enough to implant under the skin (Website of Kinetic, 2008). RFID's frequency in four different groups that including: 1) LF (low frequency) RFID systems operate at frequencies 125 and 134 kHz with a data transfer rate of around 30Kbps. Their tags are

*[1]School of Allied Medical Sciences, Tehran University of Medical Sciences, [2]Shahid Beheshti University of Medical Sciences, Tehran, Iran *For correspondence: elhammaserat@gmail.com*

often large and get reading ranges of around 1 or 2 feet. 2) HF (high frequency) RFID systems generally operate at 13.56 MHz with data transfer speed of 40-64 Kbps. 3) UHF (ultra high frequency) RFID have different frequency regulations throughout the world. 4) Microwave (WiFi) (University of California, 2007; Utrecht, 2007).

In addition, RFID can be implantable and not implantable. Implantable RFID allowing a chip to be embedded under the skin (Anderson et al., 2006; Levine et al., 2007) and that stores the patient's medical identifier. When a scanner is passed over the device, the identifier is displayed on the screen of an RFID reader. An authorized health professional can then use the identifier to access the patient's clinical information, which is stored in a separate, secure database (Levine et al., 2007). Chips in RFID system could provide numerous benefits ranging from day-to-day convenience to the increased ability of the federal government to adequately ensure the safety of its citizens (Anderson et al., 2006). The RFID tag and wristband is used for stock management and cancer patient matching (Kim et al., 2007).

RFID Capabilities within Cancer Care

For healthcare organizations, RFID is the next inevitable step towards the new generation healthcare services operations and it is set to provide new efficiencies, improved services, enhanced healthcare workflow and increased patient care for organizations seeking competitive advantage (Prakash, 2007). RFID technology has recently opened up doors to many new applications. This technology and its application within the health care environment including:

Tracking, tracing and monitoring of patients and staff

Patients must follow a strict routine of chemotherapy treatment, including frequent visits to the hospital for a simple status check (Islam et al., 2010). The use of an RFID tag attached to a patient, allows a physician to verify the correct patient, procedure and site — prior to the start of any invasive procedure. A handheld device can be used to confirm information (like the patient's Chart and ID wrist band) stored on the tag. RFID tags containing full patient histories are used in making treatment decisions (E-health-media LTD, 2006; Prakash, 2007). In addition the RFID integrates with Electronic Medical record and provides functions to improve operational efficiencies such as patient flow, asset tracking and inventory management, and produces various analytics for clinic operations . Identifiable information of cancer Patient can only be viewed by authorized staff members (Yang et al., 2010). Cancer patients need continuous follow-up because of the state of their disease and the intensity of treatment (Islam et al., 2010).

RFID applications for elders including: alert hospital (for example to patient's medications, special diet, medical conditions if patient needs emergency help), monitor (blood, insulin or other levels without physician visits), located patient with Alzheimer (Prakash, 2007).

Using RFID in staff ID badges and patient identification bands will allow the administration to be able to locate patients and staff in an instant (Dynamic Computer Corporation, 2008). With pervasive health care, cancer patients can actively participate in their health status monitoring and take proactive steps to prevent or combat the deterioration of their bodies. Without such technology, cancer patients may not have the resources to handle emergency situations (National Cancer Institute, 2012).

Tracking and tracing medical devices and equipment

Hospital staff worry they spend too much time searching for things, so they will tend to remove items from inventory and stick them in a drawer or pocket. This leads to materials management problems when the items cannot be found and used by other staff, or when they are prematurely re-ordered. RFID technology can eliminate losing by giving staff real-time locations on all items (Dynamic Computer Corporation, 2008).

Hospitals are finding it easier to manage highly mobile medical equipment such as IV pumps and wheel chairs. RFID tags are used to transmit location data to a workstation which displays the data on a floor plan of the Hospital. Trained Nurses use the software to locate the items during their daily routines. This ensures that the Hospital reduces its inventory and labor costs (Prakash, 2007).

Tracking and tracing products and materials

The tags can easily be attached to blood bags and can easily be read. The use of active RFID tags also contributed to patient safety by allowing the localization of a blood bag (Utrecht, 2007). RFID-enabled medication administration relates to the well-known "five rights" of medication administration: right patient, right medication, right dose, right time and right route (Evans, 2006). The dispensary's monitoring and andticancer drug management system in hospital may maintaining the dispensary's circumstance in fixed temperature and humidity, and confirm the right substance to the right patient (Kim et al., 2007).

Hospitals have proven that this point of care solution for specimen identification delivers higher accuracy rates than orders and labels that the lab prints centrally and distributes to the patient floors (ZHI, 2006). RFID track the total process from specimen collection in the operating Room to its being time accessioned in the pathology department (Fayad, 2012).

Tracking and tracing workflows

Medical staffs have also been given active RFID tags on badges in order to collect data on workflow to find inefficiencies in current hospital operations (Fisher et al., 2008). This system helps to ensure less wasted time. It prompts staff when there are any delays in seeing patients and allows them to enter free text explaining why there was a delay, which is useful for audits later on (E-health-media LTD, 2006).

RFID Potential Benefits in Health Environments

Patient safety has enhanced because information on the patient appears immediately on the screen when the

patient is brought into the operating theatre. Retrieval of data on contacts between patients and medical and paramedical personnel has been reduced from six hours to around half an hour. Also the mean time required for the inputting of admissions, discharges and transfers has been improved by 85%, allowing beds to be reoccupied more quickly. Patient satisfaction has increased due to reductions in waiting times and bed occupancy periods and improvements in internal transport services. In addition, you can create 'smart' operating rooms, in which surgical instruments are tagged. The room can notify surgeons if the full complements of instruments are not present (Utrecht, 2007; Dynamic Computer Corporation, 2008). In addition, RFID remind drug administration time for elderly patients (Prakash, 2007).

RFID and Privacy, Security and Legal Issues

RFID systems have captured much interest around the world. This technology has many advantages and applications in a real world situation (Ayoade, 2007). However, RFID systems introduce a key ethical concern regarding privacy because of the surveillance potential of the technology (Fisher et al., 2008). and with increasing use comes increasing concern on privacy and security. Privacy as the process of preventing the modification, misuse or denial of use, or the unauthorized use of information (Patricia, 2005).Vulnerabilities to physical attacks, counterfeiting, spoofing, eavesdropping, traffic analysis or denial of service could all threaten unprotected tags. Each of these risks may affect the privacy and security of both individuals and organizations (Weis, 2003). Some of privacy and security concerns including: 1) Who will want-and given-access to data? (Health insurance companies, Public health organizations/ registries, Market research for profiles of patients who take/do not take their medicine, where, when they take their medicines, Physician- to help better management the patient, Employers, Life insurance companies). 2) Who will be given the code? 3) Where will data be stored? 4) Range of RFID chip- who else can pick up signals? (Antokol, 2006). 5) What is nature of the data being collected, how it will be used and by whom? (Colin, 2005).

Privacy and Legal Solutions

Establishing guidelines: the repository manager must check to see if the service provider, or the data solicitor, has RFID privacy policy. If one in place, repository holders must know what is delineated. If not, they must follow the guidelines framed by law (Rakesh, 2003).

Confidentiality: means data and information are disclosed only to authorized persons, entities and processes at authorized times and in the authorized manner. This ensures that no unauthorized users have access to the information (Rakesh, 2003; Patricia, 2005).

Limiting collection: organizations should not collect or link an RFID tag to personally identifiable information indiscriminately or covertly, or through deception or misleading purposes. The information collected should be limited to the minimum needed to fulfill the stated purposes, with emphasis on minimizing the identifiability of any personal data linked to the tag, minimizing observability of RFID tags by unauthorized readers or persons, and minimizing the linkability of collected data to any personally identifiable information (Tetesa et al, 2003; Cavoukian, 2006).

Limiting use, disclosure and retention: organizations must tell when, where and how and for what purpose the data was collected while disseminating the data to third party. They should obtain additional individual consent to use, disclose or link to personal information for any new purposes, and then securely destroyed. Retailers should incorporate the data minimization principles outlined above, into and throughout their RFID information systems (Rakesh, 2003; Tetesa et al., 2003).

Accountability: an organization is responsible for personal information under its control and should designate a person who will be accountable for the organization's compliance with the principles, and the necessary training of all employees. Organizations should use contractual and other means to provide a comparable level of protection if the information is disclosed to third parties. Organizations that typically have the most direct contact and primary relationship with the individual should bear the strongest responsibility for ensuring privacy, regardless of where the RFID-tagged items originate or end up in the product life cycle (Tetesa et al., 2003; Patricia, 2005; Cavoukian, 2006).

Integrity and Accuracy: organizations should keep personal and related RFID-linked information as accurate, complete, and up to date as is needed for the stated purposes, especially when used to make decisions affecting the individual. Furthermore the data collected must not be edited and be in original format. This ensures that the information is correct and has not been improperly modified (Tetesa et al., 2003; Patricia, 2005; Cavoukian, 2006).

Availability and openness: mean data, information and information systems are accessible and usable on a timely basis in the required manner. This ensures that the information will be available when needed. Organizations should make readily available to individuals specific information about their policies and practices relating to the operation of RFID technologies and information system, and to the management of personal information. This information should be made available in a form that is understandable to the individual (Tetesa et al., 2003; Patricia, 2005; Cavoukian, 2006).

Consent: organizations must seek individual consent prior to collecting, using, or disclosing personal information linked to an RFID tag. To be valid, consent must be based upon an informed understanding of the existence, type, locations, purposes and actions of the RFID technologies and information used by the organization. Individual privacy choices should be exercised in a timely, easy an effective way, without any coercion. Consumers should be able to move, disable or deactivate item-level RFID tags, with out penalty (Colin, 2005; Cavoukian, 2006).

Identifying purposes: organizations should clearly identify and communicate to the individual the purposes for collecting, linking to, or allowing linkage to

personal information, in a timely and effective manner. Those purposes should be specific and limited, and the organizations and persons collecting personal information should be able to explain them to the individual.

Challenging compliance: organizations should have procedures in place to allow an individual to file a complaint concerning compliance with any of the above principles, with the designated person accountable for the organization's compliance (Tetesa et al., 2003; Cavoukian, 2006).

Individual access: organizations should, upon request, inform the individual of the existence, use, linkage and disclosure of this or her personal information, provide reasonable access to that information, and the ability to challenge its accuracy and completeness, and have it amended as appropriate (Tetesa et al., 2003; Cavoukian, 2006).

Safeguards: organizations should protect personal information linked to RFID tags, appropriate to its sensitivity, against loss or theft, and against unauthorized interaction, access, disclosure, copying, use, modification, or linkage. Organizations should make their employees aware of the importance of maintaining the confidentiality of personal information through appropriate training. Although physical, organizational and technological measure may all be necessary, technological safeguards should be given special emphasis (Tetesa et al., 2003; Cavoukian, 2006).

Right to now: the right of the patient to know what items possess RFID tags/ the right of the patient to access of data associated with RFID tags/ right to now to when, where, and why the data in RFID tags is accessed (Rakesh, 2003).

Attention to culture: the repository manager must evaluate the content of data to be disseminated. They must be aware cultural differences or other issues that may affect the recipient adversely (Rakesh, 2003).

Security Solutions

Several mechanisms to enhance security such as killing tags, shielding tags, locking tags, re-encryption tags, silent tree walking (Yang et al., 2006), regulation tags, selective blocking tags, anonysmous tags, and hash-based anonysmous tags (Weis, 2003; Yang et al., 2006). Security methods including :

Killing tags: The most straightforward approach for the protection of patient privacy is to kill RFID tags (Rakesh, 2003). A reader can kill a tag by sending a killing command with a short 8-bit password.

Shielding tags: tags can be shielded using special containers made of metal mesh or foil.

Locking tags: a tag with an ID saved in memory has two states: locked an unlocked. The tag can be locked to prevent revealing information using the ID.

Re-encryption tags: in re-encrypting serial number of bank notes in tags using a public key is proposed in order to reduce the linkability of different appearances.

Silent tree walking: This signal from a reader to tags in the downlink is stronger than those from tags to the reader in the uplink. There for, an adversary may hear a downlink channel far way, but may not hear uplink channels.

Selective blocking tags: A selective blocking scheme to protect patients from unauthorized scanning of RFID tags.

Anonysmous tags: User can control the uniqueness of ID from local to global without revealing the relationship between the ID and object.

Hash-based anonysmous tags: in data and location privacy are enhanced with hash-based anonysmous tags (Yang et al., 2006).

Conclusions

Cancer patient tracing improve treatment and follow up plan. RFID is an emerging technology that is rapidly becoming the standard for hospitals to track inventory, identify patients, monitoring, locate equipment, and manage personnel. RFID systems are seen as valuable because of their ability to collect data in real-time about vital signs and patient statue for decision making. This ensures that hospitals and clinics achieve improvements in availability of chemotherapy drugs supplies, less duplication and loss of equipment, and savings in inventory costs. RFID can be used for monitoring of instruments of operating room when cancer patients refer to surgery unit. The success of a patient RFID system depends on developing appropriate tools for providing security and privacy. However each of us must become familiar with the risks of RFID use. We should apply realistic and efficient security and privacy solutions and strong mechanisms against all kind of attacks. In addition, It is necessity establish international law and regulation for using RFID in healthcare environment. Limiting use, consent and attention to culture are main privacy solutions of application RFID and special tags are principle security solutions. In general, the use of RFID in health care provides a simple, low-cost solution that allows tracking and cancer care management.

References

Anderson AM, Labay V (2006) Ethical considerations and proposed guidelines for the use of radio frequency identification: especially concerning its use for promoting public safety and national security. Sci Eng Ethics, 12, 265-72.

Antokol J (2006). RFID and healthcare: privacy and security considerations. Available from www.rfidconsultation.eu/docs/ficheiros/antokol.pdf

Ayoade J (2007). Roadmap to solving security and privacy concerns in RFID systems. *Computer Law and Security Report*, **23**, 555-61.

Bin Yang, XECAN Per Halvorsen, DABR, FACR, FAAPM Alliance Oncology (2010). http://www.xecan.com/online/docs/Oncology_RFID_WP.pdf

Capgemini Utrecht (2007). RFID in health care: outcomes and points for consideration. Available from http://www.health-rfid.com/publicaties.html.

Cavoukian A (2006). privacy guidelines for RFID information systems (RFID privacy guidelines). Available from www.ipc.on.ca/images/Resources/up-rfidgdlines.pdf

Chakkunny P (2007). RFID In Health Care Organizations.

Available from http://ezinearticles.com
Chao C-C, Jen W-Y, Chi Y-P, Lin B (2004). Improving patient safety with RFID and mobile technology. *Int J Electronic Healthcare*, **3**, 175-92.
Clauser SB, Wagner EH, Aiello Bowles EJ, Tuzzio L, Greene SM (2011). Improving modern cancer care through information technology. *Am J Prev Med*, **40**, 198-207.
Dynamic Computer Corporation (2008). RFID in Health Care. Available from http://www.dcc-online.com/rfid-hardware.asp
E-health-media LTD (2006). Heartlands uses RFID for patient. Available from http://www.e-health-insider.com/news/item.cfm?ID=2317
Evans ND Where is RFID's ROI in Health Care? RFID journal, Available from http://www.rfidjournal.com
Fayad D (2012). Implementation of an Electronic Pathology Specimen Tracking System to Ensure Patient Safety, http://www.bidmc.org/QualityandSafety/QualityandSafetyImprovementsatWork/~/media/Files/QualityandSafety/1st%20Silverman%20Symposium/Implementation_of_an_Electronic_Pathology_Specimen_Tracking_System.ashx
Garg AX, Adhikari NK, McDonald H, et al (2005). Effects of computerized clinical decision support systems on practitioner performance and patient outcomes: a systematic review. *JAMA*, **293**, 1223-38.
Government Communication Office (2007). Slovenia Supports RFID, if Privacy, Health Conditions Are Met. Available from http://www.ukom.gov.si/eng/slovenia/
IOM, editor. Crossing the Quality Chasm: A New Health System for the 21st Century. Washington DC: National Academy Press; 2001. Avalaible from : http://www.ircme.ir/App_Web/(Guest)/Default.aspx?CenterID=2.
Jervis C (2005). Chips with everything: Is RFID ready for healthcare? *J Healthcare Computing and Information Management*, **22**, 5-1.
Jill AF, Torin M (2008). Tracking the social dimensions of RFID systems in hospitals. *Int J Med Informatics*, **77**, 176-83.
Kaeding P (2005). RFID medical devices - opportunities and challenges Available from http://wistechnology.com/articles/2384/
Kawamoto K, Houlihan CA, Balas EA, Lobach DF (2005). Improving clinical practice using clinical decision support systems: a systematic review of trials to identify features critical to success. *BMJ*, **330**, 765.
Kim S, Yoo S, Park J, et al (2007). Anticancer drug management system using USN and RFID. *IFMBE Proceedings*, **14**, 3988-91.
Kumar R (2003). Interaction of RFID technology and public policy. Available from http://www.rfidprivacy.us
Matthias N, Matthias J (1997). Design and Evaluation of Wireless Health Care Information Systems in Developing Countries.
Levine M, B Adida, K Mandl, I Kohane, J Halamka (2007) What are the benefits and risks of fitting patients with radiofrequency identification devices. *PLoS Med*, **4**, 322.
National Cancer Institute: SEER (Surveillance, Epidemiology and End Results) Statistics of Cancer from all sites, http:/seer.cancer.gov/statfacts/html/all.html
O Kharif, Like it or not, rfid is coming, Bus. Week Online (2004). Available from http://www.businessweek.com/technology/content/mar2004/tc20040318_7698_tc121.htm
Rezwan I, Sheikh IA, Nilothpal T, Ian O (2007). Usability of Mobile Computing Technologies to Assist Cancer Patients, USAB 2007, LNCS 4799, pp. 229–242, 2007.
Rousseau N, McColl E, Newton J, et al (2003). Practice based, longitudinal, qualitative interview study of computerised evidence based guidelines in primary care. *BMJ*, **326**, 314.
Scassa T, Chiasson T, Deturbide M, Uteck A (2005). An analysis of legal and technological privacy implications of radio frequency identification technologies. Available from www.library.dal.ca/law/Guides/FacultyPubs/Scassa/RFIDs_Report2(Single).pdf
Steven BC, Edward HW, Erin J Aiello Bowles, et al (2011). Improving modern cancer care through information technology. *Am J Prev Med*, **40**, 198-207.
University of California (2007). RFID in health care. Available from http://winmec.ucla.edu/rfid.
Website of Kinetic (2008). RFID and Healthcare: is tagging good for health? Available from http://www.kineticconsulting.co.uk/rfid.html
Weis S (2003). Security and privacy in radio-frequency identification devices Available from groups.csail.mit.edu/cis/theses/weis-masters.pdf
Xiao Y, Shen X, Sun B, Cai L (2006). Security and privacy in RFID and applications in telemedicine. IEEE communication magazine, pp70-64.
ZHI Corporate (2006). Patient Safety Applications for Bar Code and RFID Technology; http://www.danbygroup.com/systems/documents/Zebra_PATIENTSAFETY_BarCode_RFID.pdf