The Use of Emerging Technology to Improve the Performance of Health Service Delivery

Belal Chowdhury  
School of Management  
La Trobe University  
Melbourne, Australia  
M.Chowdhury@latrobe.edu.au

Clare D’Souza  
School of Management  
La Trobe University  
Melbourne, Australia  
C.D’Souza@latrobe.edu.au

Nasreen Sultana  
Emergency Department  
Frankston Hospital  
Melbourne, Australia  
n.sultana@psolution.com.au

Abstract – The objective of the research is to review the underlying principles based on performance in the health care sector. Performance indicators such as efficiency, acceptability, equity and quality are some of the measures considered. The research demonstrates the use of emerging technology (e.g., RFID - Radio Frequency Identification) to reduce health care costs and also facilitate the automating and streamlining of healthcare management process (e.g., patient and equipment identification) in hospitals. It outlines the design and application of real-time RFID-enabled Hospital Information System (HIS) applications.

Keywords – Healthcare Performance, Quality, Efficiency, RFID and HIS

I. INTRODUCTION

The concept behind performance management systems are invariably being used to improve the quality and performance of healthcare systems. While the two systems that have generally been used are the assurance systems that use summative information for external accountability and the use of formative information for continuous quality improvement for internally driven systems [1], other performance attributes that can also be included are quality of care, efficiency, access to care and the cost of care [2]. Even technical and functional aspects of qualities are given prime importance in measuring performance. These different areas of focus have implications for the type of performance management systems required and the choice of mechanisms used to determine performance.

On the global front, due to the demand for limited health resources, quality standards, efficiency (value for money), acceptability (fair access and operate ethically) and equity (fair payment, fair access to use of services and equity of outcomes) to promote a better healthcare system, majority of the Latin American and Caribbean countries reformed the health care sector in the 1990s, the United States during 1989-91, followed by New Zealand reforms in the early 1990s.

These health sector reforms introduced activities that seek to improve the health sector performance. This involved making fundamental changes in the way healthcare is organized, financed, and paid for, with legal mechanisms that were used to regulate care. Most of these reform initiatives formed part of larger governmental reforms that were aimed at improving the efficiency of the public sector. The major aim of these health reforms was to increase efficiency, improve quality of care from a technical standpoint and user’s perspective, expand coverage, and equity between groups [3, 4]. A 2000 multi-country evaluation reported that very few countries had been able to document improvements in healthcare quality or in public perceptions about quality of care [5]. It may be suggested that in the presence of broad-scale health sector reforms that emphasizes on a strong force for change, quality assurance programs can assist with the point of service delivery, allowing healthcare managers and providers to navigate through the system to maximize health outcomes for the communities they serve [6].

The objective of the research is to review the underlying principles based on performance in the health care sector. Performance indicators such as efficiency, acceptability equity and quality are some of the measures considered. The research demonstrates the use of emerging technologies such as RFID (Radio Frequency Identification) technology to reduce health care costs and also facilitate the automating and streamlining of healthcare management process (e.g., patient and equipment identification) in hospitals.

i) Efficiency is an important performance requirement. Sir Peter Gershon identifies efficiency as “making the best use of the resources available for the provision of public services.” Efficiencies can be achieved [7] by

a) reduced numbers of inputs (e.g. people or assets), whilst maintaining the same level of service provision; or
b) lower prices for the resources needed to provide public services; or

c) additional outputs, such as enhanced quality or quantity of service, for the same level of inputs; or improved ratios of output per unit cost of input.

In healthcare context (i.e., changes in the patterns of demand and supply), accounting for a sizeable proportion of national expenditures, and the coordination of care has become a key policy response to improve efficiency and effectiveness of health care delivery. Efficiency reduces medical errors, cost efficiency and cost effectiveness. It is also suggested that this leads to higher workforce productivity – e.g. through reduced sick leave – overall economic efficiency will also improve.
Efficiency justifies a system’s ability to function at lower costs without diminishing attainable and desirable results [8]. Thus the efficiency as a performance measure in the health care sector denotes not only cost effectiveness but also value in terms of quality and service. The other two measures of performance are acceptability and equity that are of secondary importance.

ii) Acceptability - The level of satisfaction or acceptance expressed by patients, communities, providers (e.g., hospitals) and degree of courtesy and consideration afforded them by the health care system. Acceptability ensures the conformity to the realistic wishes, desires and expectations of healthcare users and their families [8].

iii) Equity - Braverman and Gruskin, a US health and human rights academics identified equity as “an ethical concept grounded in the principle of distributive justice [9]. Equity conveys a sense of fairness, but sharpens fairness by adding equality and fellow-feeling. Equity is an ethical value and is not the same as equality, which simply implies similarity of status, capacity, or opportunity [10, 11]. The issues of equity are intimately linked to issues of choice and that the extent of inequity in a given situation depends on the extent to which that situation arose from individuals choices [32].

iv) Quality - The Institute of Medicine (IOM) and Organisation for Economic Cooperation and Development (OECD) identified quality of care as “the degree to which health services for individuals and populations increase the likelihood of desired health outcomes and are consistent with current professional knowledge” [12, 13]. While, the state of quality in the healthcare system continues to be pervasive, and occurs across all types of delivery systems, there is a dearth of research on performance systems and evidence of their effectiveness in enhancing the quality of care [1]. Some research from studies of assurance systems in hospitals has published performance data that examined attitudes [14].

Generally, over the last decade, various health system reforms in Australia, as in many OECD countries, have tried to contain costs and achieve greater efficiency while ensuring the quality of health care [11]. As it can be seen, health care providers pursue different courses of action to improve the care in terms of quality and efficiency. However, these have not met with promising results. For instance, a survey in the US reported that about one in seven say that they are dissatisfied with the quality of care they are given [15]. Furthermore, in most of the developing world, health care is becoming patient-centric, this has triggered due to the role consumers play in health care determinants [16]. Nonetheless, the health care industry has been slow in using technology as compared to other industries. This could be attested due to reluctance from health professionals (doctors, nurses) to accept changes and the apprehension of the negative impact of their overall efficiency.

Furthermore, the quality care is determined not only by, say, technological advances in preventing and treating disease but also by health providers’ (e.g., hospitals) ability to deliver the benefits of those advances to patients. Thus is can be seen that there is a constant need for improving quality in services, especially in cases where technology advances. In this paper, we outline the present status in services of health care.

II. PRESENT STATUS IN SERVICES OF CARE

Patients today demand quality in technology and services. Technology offers computer-based solutions for improving medical care and making healthcare organizations more efficient. The contemporary definition offered by Kotler and Armstrong in (1991) suggests that a service can be an exchange of an activity or benefit which is intangible which may or may not be tied to a product.

Services have characteristics that distinguish them from products and can be described as intangibility, inseparability, variability, perish ability and inability to own a service. These characteristics are used in order to understand the nature of service offered. International Standards Organization (ISO) 9004 has highlighted the fact that a good quality service can lead to cost reduction, improved productivity, efficiency and customer satisfaction [17].

The main players in today's healthcare industry are consumers, providers, payers and regulators. Consumers are the one, who uses healthcare services. Anyone who is involved in any way in delivering healthcare to consumers is a provider, which includes doctors, hospitals, insurance companies, pharmacies, drug companies, and others. The government and consumers are the payers, and finally, healthcare is subject to a plethora of federal and state regulations.

With respect to technology, researchers have expanded the services triangle to into a pyramid as shown in Figure 1. The pyramid indicates that the interactive services can be the outcome of consumers, service providers (i.e., hospitals, nursing homes, health clinics, etc.) and technology, interacting at a given point in time to provide a service. It is the government’s responsibility to provide the technology and the service provider to ensure service quality to their patients in healthcare system [18]. Government support appears critical for the smooth operation of such a service.

Traditionally, research of quality measurement and improvement has centred on services and manufacturing industries. However, the focus has shifted more recently to the measurement of quality in healthcare sector. In today's competitive environment, healthcare providers (e.g., hospitals) increasingly realize the need of service quality as a means to improve their competitive position.

Quality of service provision in healthcare involves with different stakeholders might place different emphasis on different aspects of quality. Clinicians typically emphasize clinical quality, whether the service provided safely and achieved expected outcomes of care. Whereas consumers, on the other hand determine quality of services based on
timeliness of access and cultural appropriateness [4]. In comparison, the performance of health care management system is far behind when compared to the services and manufacturing industries. Health care providers such as hospitals are dealing with greater rank diseases, their cost, quality and delivery has essentially not improved significantly, despite the difference with the other industries seems to have increased [19].

Gronroos (1984) indicated that the ‘technical’ and ‘functional’ qualities are the two main elements of quality. The technical quality refers to relatively quantifiable features of a service such as waiting time in the emergency situation in hospitals, service reliability as they can be easily measured by the patient and the service provider (i.e., hospitals). On the other hand, the functional quality indicates that how the technical quality is delivered to patients and how do the environmental factors (i.e., context-aware) influenced them.

Patient safety is of key significance and a main determinant of the quality of healthcare services. Patient safety is critical to the sustenance modern healthcare systems. Safety is identified as issues related to the unintended outcomes (i.e., medical errors, lack of communications between health professionals, etc.) of hospital care and quality is taken as intended outcomes of care that interpreted across a number of dimensions including timeliness, acceptability, sustainability as well as overall care outcome. Being a multi-factorial problem, patient safety requires improvement interventions on multiple levels including individual, team and organization as a whole [20].

The National Coordinating Council for Medication Error Reporting and Prevention (NCCMERP) defines a medication error as "any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of the healthcare professional, patient, or consumer" (2004). These errors can occur at any stage in the medication process, which includes prescribing, order communication, product labeling, packaging, compounding, dispensing, distribution, and administration [21, 22]. The statistical results for wrong time shows around 43%, omission (30%), wrong dose (17%), and unauthorized drug (4%). The number of these errors deemed potentially harmful adverse drug events (ADEs) or harmful medication errors was 7%. A comprehensive review of medication error studies cited in the IOM 2000 report on errors in the U.S. healthcare system suggests that preventable ADEs occur in 1% to 10% of hospital admissions. The IOM report further estimated that 770,000 patients are injured and 7,000 die each year due to medication errors. The added costs associated with treating medication errors can be very high [22].

Australian healthcare system will be facing a number of significant performance challenges over the next decade. For instance, ageing population is not the only traditionally lamented issue that driving health care cost out of control. Instead, the key problem facing the healthcare system is internal ones: ensuring consumer (e.g., patient) safety and quality, choices about roles of health professionals (e.g., doctors and nurses), lack of communication between health professionals, addressing the inequalities in health outcomes, and addressing technical and allocative efficiency. Concerns about health system viability, efficiency, and effectiveness will continue to be addressed in the 21st century [4].

The healthcare policy in Australia has been to reduce the stock of hospitals in line with changing methods of managing patients. Although the number of acute hospitals in Australia has increased slightly from 1,278 in 2002-03 to 1,282 in 2006-07, bed capacity has not increased substantially [23]. NSW Minister for Ageing Kristina Keneally identified that the state government faced the prospect of a budget crisis in 2030, when the number of people aged over 65 was expected to double [24]. A recent AMA (Australian Medical Association) report has revealed that a third of emergency patients not being treated within target times (i.e., 30 minutes) and up to 1500 unnecessary deaths each year due to overcrowding in Australian public hospitals. The report found that 67% of beds had been cut in the past 20 years across Australia, and the impact of these cuts is causing a serious problem [25]. Improving safety and quality of care may involve multiple actors, starting at the emergency department, medical ward or unit level, supported by a clear commitment from facility or hospital management and from government.

The length of treatment and care needed for patients with chronic illness and the requirement of medical attention for mundane checkups take away health professionals valuable (nurses, doctors, consultant or GP) time and this again adds to the problem of considerable waiting time in the healthcare system. In order to tide over this situation the remote monitoring and disease management programs (e.g. patient-centric approach) are needed to provide continuous disease management support systems so that aged people and patients of chronic illness can fend for themselves [26]. In today's context of escalating costs, managed care, regulations such as the Health Insurance Portability and Accountability Act (HIPAA) and a technology savvy patient, the healthcare industry can no longer be complacent, there is a strong need to use innovative technologies to enable better, more effective and efficient practice management.

In a technology-based environment, m-commerce or mobile/wireless solutions are expected to provide real-time
This paper is structured as follows: Section III outlines the multi-layer architecture for HIS via both wireless and wired network integrating smart RFID tags and data processing into a single integrated system [30].

The application of the above principles can be facilitated by the use of emerging technologies such as Radio Frequency Identification (RFID). RFID is one of the wireless technologies that elegantly provide a solution, and assist healthcare facilities by detecting and tracking a patient, equipments/assets and their location in real-time. The benefits of having RFID-based healthcare system are enormous, for instance to improve health care quality, prevent medical errors, reduce health care costs, increase administrative efficiencies, decrease paperwork, and expand access to affordable care, an issue that is of concern to governments worldwide [29]. Today's advanced technology is capable of uniting smart RFID tags and data processing into a single integrated system [30].

In this paper, we integrate RFID technology with a multi-layer architecture for HIS via both wireless and wired network to improve performance of health service delivery systems. This paper is structured as follows: Section III outlines the RFID model used for developing patient identification and monitoring system. Section IV illustrates the application of patient monitoring systems architecture using a RFID-enable HIS. Section V concludes the paper.

III. RFID MODEL IN HEALTHCARE SYSTEMS

Healthcare providers (i.e., hospitals) traditionally use paper-based ‘flow chart’ to capture patient’s information during registration/admission time, which needs to be maintained and transferred between departments. Nurses play a vital role in the hospital system in the success of both inpatient and outpatient care. They also play a very important role in executing clinical orders and in communicating information between the hospital and the patient.

RFID-enabled medical applications can use the health information for business support via wireless network. A patient tag or RFID encoded wristband (i.e., tiny chips) can be issued to every patient at registration, and then it can be used to identify patients during the entire hospitalization period. It can also be used to store patient’s basic information (e.g., patient id, name, age, blood group, drug allergies, drugs that the patient is on today and so on). Each patient tag is identified by its Unique Identification Number (UIN) that can be programmed either automatically or manually and then password protected to ensure high security. RFID encoded wristband data can be read through bed linens, while patients are sleeping without disturbing them. The RFID model facilitates the structure that can seamlessly integrate the captured data at various levels in the healthcare business process with the backend databases, backend applications and decision support system.

The main components of RFID-based HIS is shown in Figure 2. It mainly consists of a patient tag (i.e., wristband), a reader and health care provider IT systems (i.e., Real-Time RFID-Based HIS). Each unique patient tag can be passive, semi-passive or active. Passive patient tags can be used for both reading/writing capabilities by the reader and do not need internal power (i.e., battery). They get energized by the reader through radio waves and have a read range from 10mm to almost 10 meters. Passive tags are cheap, ranging from $0.25 to $0.40 each and life expectancy is unlimited. We suggest the use of passive patient tags (13.56 MHz ISO 15693 tag) with the read range of one meter, and PDA/Next G Smart Phone RFID readers for the real-time Healthcare Management System (i.e., HIS) application [31].

The passive patient tag antenna picks up radio-waves or electromagnetic energy beamed at it from an RFID reader device and enables the chip to transmit patient’s unique ID and other information to the reader device, allowing the patient to be remotely identified. The reader converts the radio waves reflected back from the patient tag (i.e., wristband) into digital information then pass onto HIS system for processing.
Internet into other health centers databases for retrieving patients past history. Although with a whole real-time RFID-based HIS system approach and integration with other medical applications, there is the exciting potential of delivering more efficient patient care through higher levels of compliance with care pathways.

IV. RFID-ENABLED HIS APPLICATION

As the healthcare industry faces data integration issues, the RFID device management is a challenge while deploying RFID devices in their health provider’s system. Multi-layer RFID architecture establishes an infrastructure to address such a challenge, to automate and simplify the functionality for building RFID-based solutions in the healthcare system. These integration layers (i.e., five layers) are namely, physical device layer, middleware layer, IT infrastructure management layer, data layer and graphical user interface layers.

The physical device layer consists of the actual RFID hardware components (such as RFID tag, and reader) that integrate with HIS for capturing data automatically. The middleware layer or framework is viewed as the central nervous system from the healthcare system perspective. It acts as the standard mechanism to get a quick connectivity between patient tags and RFID-enabled healthcare providers IT systems as shown in RFID model in Figure 2.

The IT infrastructure management layer is responsible for managing and controlling the healthcare provider’s IT components such as computers, back-end servers, networks, and printers. In addition, this layer enables data mapping, formatting, business rule execution and the service interactions with back-end databases. The data layer composed of a RDMS (Relational Database Management System) and it interacts with a back-end database (SQL server) and includes a data query/loading approach using SQL (structured query Language) that supports high volumes of RFID data into a custom designed RFID database schema. Finally, the graphical user interface (GUI) layer is comprised of an extensible GUI (graphical user interface) helps in managing the information, generating various reports and analyzes the information at various stages in the entire value chain.

Figure 3 (a), 3(b) and 3(c) shows the RFID-enabled HIS application, which can be integrated with the healthcare providers IT System for capturing patients, medical equipment, or assets data and their location automatically and wirelessly. The system is developed in Microsoft Visual Studio.net 2003 environment using Visual C++ (MFC). The RFID-based HIS application issues a unique tag ID to every patient with a wristband at registration/admission in hospitals is shown in Figure 3(a). The RFID then uses the tag ID as a key to information and perhaps other information (e.g. name, DOB, drug allergies, blood group, etc.) stored in the health providers back-end databases (i.e., SQL server).

V. CONCLUSIONS

The paper demonstrates how to apply RFID techniques in the healthcare system. We have shown how the RFID-based system architecture and HIS application can improve
healthcare quality and performance. It forms the basis of using HIS, health care providers (e.g., hospitals) that have a chance to track fast and accurate patient identification, improve patient’s safety, prevent/reduce medical errors, increases efficiency and productivity, and cost savings via wireless network. Given this opportunity the HIS may be in a better position to assist hospitals to build a better, more collaborative environment between different departments, such as the wards, medication, examination, and payment.

For the health care provider the implications are substantial. Using the efficiency and effectiveness of the RFID process can provide vast benefits to patients. For instance, maintaining his or her own personal records would help to eliminate duplication and give a historical account of the patient’s well being. More in-depth information of particular patient enhances the efficiency and effectiveness of self-managing their health. It is our expectation that future experimental research will be able to provide a more in-depth analysis for substantiating the above model, which will help in assisting with public policy initiatives.

REFERENCES


