

Strategic Plan and Development Projects for Modern Health Clinical Information Systems at King Saud Medical City

Deena M. Barakah, Ayman M. Alrobia, and Sami Alwakeel

Abstract—It is widely acknowledged that information technology plays a critical role in improving health care performance and productivity.

In this paper, we present a survey of various IT systems recently introduced for a tertiary healthcare enterprise in the kingdom of Saudi Arabia. The enterprise hospitals constitute King Saud Medical City (KSMC) of Ministry of Health at Riyadh, Saudi Arabia. The paper discusses the KSMC hospital IT department objectives, and strategic plan for IT infrastructure, the vigorous development stages, and a brief summary of its impact on KSMC work performance.

KSMC IT program innovative approach to clinical systems development, presented in this paper, may enhance the professional knowledge for introduction of IT – based clinical systems at similar tertiary healthcare hospitals.

Index Terms—Health information systems, clinical systems, Strategic planning for IT health systems.

I. INTRODUCTION

One major requirement for an improved health care service in world countries is the introduction of new health care technologies and clinical systems. Saudi Arabia is no exception. In recent past, a few hospitals in Saudi Arabia have introduced these systems using commercially available products. In order to fulfill the country's healthcare objectives, the Kingdom of Saudi Arabia has endeavored to reorganize and improve its major hospitals IT systems. The Saudi ministry of health has undergone profound change and significant progress for implementation of advance and new IT clinical systems. A comprehensive program for development the IT system in major Saudi healthcare enterprises was recently executed. The ministry program is one of leading health programs in the region and aim toward the enhancement of productivity of its healthcare services. King Saud Medical City Hospital (KSMC) is one of leading health enterprise in Saudi Arabia that aim toward the development and implementation of IT to enhance productivity of its healthcare services.

Since 2006, KSMC has moved toward implementing integrated health care information systems that apply IT technology in innovative ways to drive higher levels of

clinical performance.

KSMC is a modern, tertiary care referral hospital that provides the highest national standards of healthcare and clinical services.

The hospital was founded in 1956 under the name King Saud the First and is considered one of most prominent and oldest hospitals in the kingdom. Later, the name was changed to King Saud Medical Complex. Recently, it was renamed King Saud Medical City after it went through a major transformation into an integrated medical city with world class services. The carried out transformation included a major administrative, technical, medical and organizational restructuring. It currently contains three major hospitals namely: General, Children and Obstetrics hospitals that integrate a research center and departments of surgery, internal medicine, physiotherapy, gynecology, obstetrics, pediatrics, dental, in addition to central laboratory, blood bank, emergency, prosthetic, kidney dialysis and outpatients clinics [1]. KSMC vision is to be the pioneer health organization in providing the most distinctive health care in the Kingdom. It has 1200 ward beds in addition to 140 intensive-care unit beds. KSMC has approximately the following statistics: OPD Visits = 900, average daily census = 840, number of doctors = 1552, and average daily number of emergency patient registrations from all ER = 800. Based on its bed capacity, KSMC is by far the largest hospital of Saudi Arabia Besides, providing typical health care to its patient, KSMC's Emergency department is one of the busiest in the country with a high experiences staff to treat variety of accident and emergency cases. KSMC also is an internationally recognized centre for training in term and post-graduate doctors in medicine and surgery. Consultants, specialists, registrars, residents and interns from all specialties and sub specialties form teams within each departments with cases referred to the department are discussed by the team members before final treatment decision is made by the consultant. Thus the patient and the team of doctors are benefited equally and learn from the consultant education and experience. As a result of its distinguished performance, quality of service and facilities, KSMC recently obtained the Accreditation Standards for Hospitals from the Joint Commission International (JCI), globally recognized as the world's pioneer in medical facilities accreditation.

One area of transformation that has undergone profound change and significant progress at KSMC is development of its medical and clinical IT systems. Advance IT systems and infrastructure were introduced and Programs have been created and implemented in a new IT department.

Manuscript received Febraury 5, 2014; revised April 30, 2014. This work was supported by King Saud Medical City.

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In this article, we present strategic KSMC plan for IT infrastructure, a survey of the hospitals IT clinical systems and a brief summary of its concrete accomplishments. KSMC's innovative approach to IT structure and clinical systems development, presented in this paper, can serve as a model for other similar healthcare organizations undergoing rapid computerization and for health enterprises and hospitals with similar medical and clinical needs.

II. STRATEGIC PLAN DEVELOPMENT AND IMPLEMENTATION FOR HEALTH CLINICAL SYSTEMS

It is widely acknowledged that information technology plays a critical role in improving health care performance and productivity. Yet little is known about their implementation at community hospitals in developing countries. A few hospitals in Saudi Arabia have recently introduced these systems using commercially available products. [2]-[4] In the light of the importance of successfully implementing these clinical systems in such settings, we present in this section various experience learned from strategic planning and development of IT clinical systems at the King Saud Medical City.

The first step towards the establishment of advanced IT clinical systems in Saudi hospitals came when the Saudi government at year 2000 approved a health reform committee to conduct a comprehensive review of the health care services provided to the Saudi citizens. [4]. The committee report emphasized the need for comprehensive programs and plans for introducing IT systems in all healthcare sectors [5], [6]. In addition to the lack of sufficient and high-quality IT health systems, the committee has found a severe shortage of health informatics nationals and who could efficiently implement IT in clinical fields and health sectors. As a result, the Ministry of Health (MoH) approved a strategic plan and a national e-health program for computerization of its national health sectors [7]. A national information technology general administration linked to the ministry of health was established to implement the plan. Besides, a range of initiatives were launched, aimed at further boosting the Kingdom's healthcare sector competencies through training, technology advancement and medical and health knowledge-sharing.

It was clear from the onset that the successful implementation of a kingdom-wide health IT systems could only be achieved by a thoroughgoing intensive and parallel coordinated efforts in all ministry of health facilities and organizations. In the meanwhile, the fulfillment of the Kingdom's health manpower, systems and infrastructure requirements demanded the development of several medical cities that provide advanced Tertiary and Quaternary health to patients in various regions of the Kingdom. King Saud medical city was restructured to provide such advanced health service for residents and citizen of Riyadh region. The establishment of these cities in turn necessitated the development of a comprehensive IT implementation programs to supply the required manpower and infrastructure for its operation and management. Each medical city was given the authority to establish its IT task force and to form

its own teams to build cadres specialized in the field of health informatics and to implement its various clinical systems according to the general guidelines and specifications set by MoH national IT health administration.

KFMC management cooperated with various information technology (IT) firms to launch an ambitious Plan for E-health infrastructure, health and clinical systems within its hospitals. The E-health plan consists of several key components:

- Development of a new integrated health Information System (HIS) to manage and optimize KSMC work flow process and to provide reporting support to its management and staff. ;
- Electronic scheduling of appointments for patient treatment and hospitalizations that will be available all KFMC professionals and patients;
- E-prescribing, which will allow electronic prescriptions filled by physicians to flow to both the KFMC pharmacy and the Prescription checking officials that implements KFMC quality assurance policy and the hospital inventory. The system will also include various support functions, such as clinical recommendations or warning for drug allergies;
- Improved broadband wired and wireless networks to facilitate access to Internet digital libraries and communication across the KSMC various hospitals and with the national IT administration at the ministry of health.
- Implementation of an advanced picture archiving and communication system to provide efficient storage and convenient access to, clinical images from multiple modalities and to eliminates the need to manually store, retrieve, or distribute clinical images; and
- Implementation of a laboratory information management system integrated with the KSMC HIS.
- Development of electronic patient Medical Records (EMR) in accordance with the ministry of health directives and specifications, which will constitute a central data repository of KFMC patient data available to all health care provides;

The plans for the all elements, with exception of a full EMR, have started projects for full implementation. KSMC will phase in the national patient EMR as targeted by the ministry of health strategic E-health plan. This is expected to be implemented upon completion of the Saudi standard records formats, and communication protocols to enhance interoperability among Saudi hospitals.

In what follows a detailed summary of the KSMC development projects of various clinical and health information systems.

III. KSMC INFORMATION AND CLINICAL SYSTEMS DEVELOPMENT PROJECTS

Medical informatics aims toward studying and enhancing the information organization, analysis, management, and implementation in health care [8]. Over the past three decades, medical information has grown and applied at an exponential rate in numerous clinical systems that can collect, analyze, store, retrieve and distribute health and medical

information. In particular, medical and health informatics have significantly contributed to the emerging and development of the following main systems [9].

- 1) Electronic Health Record Systems
- 2) Healthcare Organizations management and administration.
- 3) Consumer Health Informatics and Tele-health systems.
- 4) Public Health Infrastructure and systems.
- 5) Patient-Care Systems.
- 6) Patient Monitoring Systems.
- 7) Radiology Systems.
- 8) Medical Laboratory systems.
- 9) Information Retrieval and Digital Libraries.
- 10) Clinical Decision-Support Systems.
- 11) Health Science Education networks and systems

Most of these systems were implemented in the daily work of clinical practice at hospitals, medical and health centers worldwide. Studies have shown that they have a tremendous impact for improving the health care quality, safety, and efficiency by preventing medical errors, reducing health and medical care costs, and helping physicians and patients in the management of various health care conditions [3].

As it is very common in health industry, implementation for information technology in KSMC medical and health establishments constituted of the diffusion of IT technologies in three main sectors namely: administration, clinical, and healthcare Infrastructure.

Table I shows the developed health information technology applications for Organizational and Health Care Practitioners at KSMC.

These various legacy IT systems were build by the vendor based on KSMC work flow and practice. The platform for it at the early stage of implementation was Oracle 9 GUI and SUN Solaris UNIX hardware. During two year after its installation, major upgrades were carried to the above systems and other systems were also added including Order communication System, Infection Control Information System, Drug Information System, Housing Information System, and a General Ledger System for Government Sector.

The implementation missions were based on the following basics:

- 1) Introduction of a comprehensive set of IT clinical systems for all KSMC healthcare services.
- 2) All of KSMC IT Clinical systems should integrate with each other by following HL7 standards, guidelines, and methodologies.
- 3) KSMC IT system should be capable to communicate with MOH systems and various outsiders' healthcare systems at the kingdom.
- 4) Software Provider teams, have to work together with the highly skilled KSMC employees, to customize IT clinical systems.
- 5) Establishment of a committee of Health Informatics specialists & IT Engineers to support implementation of new IT clinical systems & to assist in overcome difficulties facing users of current systems.
- 6) Carry scientific research for the evaluation of implemented IT clinical systems in providing improved health care at KSMC.

TABLE I: EXAMPLES OF INFORMATION TECHNOLOGY APPLICATIONS PLANNED AND DEVELOPED AT KSMC

IT Applications Category	Health Care Practitioners IT Applications	Health Care Organizations IT Applications
Administration and finance	<ul style="list-style-type: none"> • Billing • financial Accounting • Patient E-Scheduling • Personnel and payroll 	<ul style="list-style-type: none"> • ERP Integrated System • General ledger • Service sale • Patient Information Filing • HR & Payroll • Inventory management
Clinical	<ul style="list-style-type: none"> • Lab tests and clinical information On line retrieval • Electronic prescription • Electronic Medical Record 	<ul style="list-style-type: none"> • Computerized provider order entry (CPOE) • Electronic Medical Record • Medical Images archiving & Distribution • Lab Tests Reporting • Body area networks • Surgical Robots • Elderly & ICU Patient monitoring • Tele-Medicine
Support Systems	<ul style="list-style-type: none"> • E-mail & Chatting communication • Clinical decision support systems • Digital Libraries • Web sites 	<ul style="list-style-type: none"> • Clinical decision support systems • Medical Simulation & Virtual reality • Clinical Databases • Medical Portal • E-Learning
Hardware & Infrastructure	<ul style="list-style-type: none"> • Smart phones , tablet & personal computers • Servers • Wired & Wireless Networking 	<ul style="list-style-type: none"> • Desktop and & laptop computers • Servers • Wired & Wireless networks • Voice recognition systems • RFID, Bar coding , NFC technologies for inventory control drugs, medical devices. • Security systems

At a later stage of E-health plan implementation, KSMC created an extensive fiber optics network that cover all KSMC hospitals and departments, with more than 2000 nodes and provided hundreds of work stations , desktop computers to all hospitals offices, nursing stations , reception units, physicians' charting rooms, and clinics.

By year 2006, installation of a legacy Health Management Information Systems (HMIS) was completed with the following systems and applications:

- 1) Access & Security System
- 2) Master Index Patient Registration System
- 3) Outpatient and Inpatient Management System
- 4) Radiology Information System
- 5) Nutrition and Diet Information System
- 6) Emergency & Accident Management System
- 7) Patient Records System based on the International Classification of Diseases (ICD9)
- 8) Blood Bank Information System

- 9) Pharmacy Management System
- 10) Account Receivable System
- 11) Inventory Management System
- 12) Laboratory Information System
- 13) Engineering Management System
- 14) Mortuary information System
- 15) Artificial Kidney Unit Management System

By end of 2008 many new special purpose clinical systems were added to the HMIS such as Appointment & Referral System, Intensive Care Information System and Infection Control Information System. The platform for the administration and financial IT systems was also transformed to Oracle 10G-Web Enabled and Microsoft Windows (client/server and Web enabled Architecture).

Afterward, several of these legacy systems were replaced with international modern clinical and administration systems as per MOH strategy. A set of the most advanced health information and clinical systems were introduced at KSMC according to E-health plan to improve patient care quality and safety including : Integrated Clinical Information System (ICIS), Laboratory Information Management System (LIMS), Computerized Physician Order Entry system (CPOE) and Picture Archiving and Communication system (PACS).

Furthermore, wireless network Solutions were installed at various KSMC hospitals and clinical wards to allow physicians using their PDA and smart phones to perform various health care clinical tasks such as access patient records, or to verify patient prescriptions.

KSMC hospital is also planning to expand in near future, the use of wireless solution to include active radio frequency identification (RFID technology for real-time patient tracking and to track hundreds patients files throughout its facility. The objective is to remove inefficiency associated with inter-departmental communication, patients' beds allocation and to improve patients admission process. The use of RFID will also allow other features to be embraced, such as reducing patient's blood transfusion errors and ease of KSMC assets tracking [10].

IV. IT CLINICAL SYSTEM PERFORMANCE IMPACT

Upon implementation of these systems, it was noticed that there exists a lot of support by KSMC physicians and allied health professionals for its implementation [2], [11].

In a research study carried to estimate the adoption rates of wireless Personal Digital Assistants (PDAs) and Smart phones among KSMC physicians and dentists, for improvement of the quality of health care, showed that PDA and Smart phone prevalence (use) rate among them is 69.1%[10]. About 90.0% of female and 88.9% of male KSMC staff strongly agreed that PDA improve their performance and their work productivity. Most common application used for the PDA was for accruing drug information data (with 97.4% of KSMC health care providers) followed by using PDA for medical research (63.2%). The study shows that at KSMC, PDA advanced technology devices have become a valuable and popular tool at patient point of care.

In the light of the importance of introducing CPOE systems in clinical settings, another research study was carried

out to assess the adoption of CPOE by attending physicians and dentists at KSMC [2]. The study involves the evaluation of CPOE impact of on physicians work performance in providing a quality medical care. The research results proved that CPOE implementation resulted in a saving of up to 45% of medication wastage, and a reduction of more than 90% in medication transcription errors in KSMC pharmacies. In addition, it was estimated that the KSMC physicians' satisfaction level with the CPOE implementation was more than 80 %.

One area that needs further investigation, was the interoperability of KSMC advanced diverse stand-alone and department specific clinical systems. To overcome it, KSMC imposed a requirement of all its clinical systems to be HL7 compliant. Another difficulty that impacts the work performance was the workflow delays at times of system failure, and the increased time that it takes for a physician to get used to such advanced IT clinical systems. The barriers to obtain the full benefits of several clinical systems were mainly: users computer literacy problems, and lack of patient awareness. However, with well designed systems, accompanied with good health care providers training, it is expected that KSMC physicians acceptance and satisfaction will be strongly enhanced, and rapid adoption of these systems can be achieved.

V. CONCLUSION

This paper presented the strategic planning and development in IT and health information systems at KSMC. Discussion is included for the diffusion of IT technologies and its applications for King Saud Medical City Hospitals Organizational activities and for its Health Care Practitioners.

ACKNOWLEDGMENT

The authors would like to thanks Dr. Saleh Altamimi, the General Supervisor of KSMC for his continuous support and encouragement.

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