The 2006 International Arab Conference on Information Technology (ACIT'2006)

E-HEALTH IN BAHRAIN: THE MEDICAL EQUIPMENT PERFORMANCE RECORD (MEPR)

Zaitun Abu Bakar, Mohd. Safwan Termanini, and Wasan Shaker

Department of Information System
College of IT,
University of Bahrain.

ABSTRACT

A driving force in healthcare is to offer the proper treatment with minimum risk and the fastest recovery. Biomedical equipment and devices play a pivotal role in the continuum of patient care. This paper describes the benefits of the Medical Equipment Performance Record (MEPR) and the technologies that have facilitated the development of a prototype. We consider MEPR a very important and significant example of a life-spanning system.

The paper starts with a brief description of the government efforts in developing e-health services in Bahrain and its challenges. This is followed by a description of MEPR, its objectives, architecture and its challenges. The focus of the paper is then directed towards the development of a prototype system and the presentation of some screen shots of the system.

Keywords: *e-health, healthcare, medical equipment performance record*

1.0 INTRODUCTION

The World Health Organization defines e-Health as the cost-effective and secure use of information and communications technologies in support of health and health-related fields, including health-care services, health surveillance, health literature, and health education, knowledge and research" [1]. e-Health is expected to improve various aspects of healthcare (quality, cost-efficiency, access ...) by:

- Supporting the delivery of care tailored to individual patients, where ICT enables more informed decision-making based both on evidence and patient-specific data;
- Improving transparency and accountability of care processes and facilitating shared care across boundaries;
- Aiding evidence-based practice and error reduction;
- Improving diagnostic accuracy and treatment appropriateness;
- Improving access to effective healthcare by reducing barriers created, for example, by physical location or disability;
- Facilitating patient empowerment for self-care and health decision-making;
- Improving cost-efficiency by streamlining processes, reducing waiting times and waste.

The Kingdom of Bahrain is in a region currently experiencing an oil boom of unprecedented proportions. It is the fastest growing economy in the Arab world, the United Nations Economic and Social Commission for Western Asia found in January 2006. Bahrain also has the freest economy in the Middle East according to the 2006 Index of Economic Freedom published by the Heritage Foundation/Wall Street Journal, and is twenty-fifth freest overall in the world.

In Bahrain, petroleum production and processing account for about 60% of export receipts, 60% of government revenues, and 30% of GDP. Economic conditions have fluctuated with the changing fortunes of oil since 1985, for example, during and following the Persian Gulf crisis of 1990-91. With its highly developed communication and transport facilities, Bahrain is home to numerous multinational firms with business in the Persian Gulf. A large share of exports consists of petroleum products made from imported crude. With the current state of the economy, the Kingdom is concentrating on

implementing e-government and one of the flagship applications is e-health.

The Ministry of Health is working on improving healthcare services to citizens of Bahrain. One of the essential steps towards achieving this goal is through proper record maintenance of medical equipment records.

In the world of finance, all loans transactions are tracked and reported to a trusted agency. Most people are familiar with credit reporting. The credit information is collected and appended to a unique consumer record. This historical credit information provides an "actual" profile representing a consumer's payments of their financial obligations. Creditors and financial institutions minimize their risk by retrieving credit reporting, before they extend financial aid to a customer. Throughout the financial world, registries of consumer payment history has reduced bad debts, fraud and crime, and streamlined the loan process. It is a reliable and reputable source for consumers' lifetime financial profiles.

There are other lifetime Performance Records such as: the Longitudinal Criminal Record (LCR), the Longitudinal Job Record (LJB) and the Longitudinal Patient Record (LPR). In healthcare, patient clinical data is collected in secure central repositories and trusted agencies such as hospital associations. This clinical data is processed and converted into significant reports to assist healthcare organizations in establishing ***"quality metrics"*** for patient care [4, 5, 6].

2.0 THE PROPOSED SOLUTION – MEPR

For the Kingdom of Bahrain, we propose the adoption of a system that is capable of managing all medical equipment data, which will directly contribute towards ensuring excellent medical treatment of its citizens. The Medical Equipment Performance Record (MEPR) is secure web-based repository managed by a trusted agency. It enables a Hospital-to-Hospital (H-2-H) and vendor-to-Hospital (V-2-H) exchange of information on all life-supporting biomedical devices [4]. MEPR is not just a repository of incidents reported by healthcare providers, but the ***legitimate custodian*** of all biomedical device performance records used in any healthcare facility. Effectively, the MEPR becomes an authoritative reference of unbiased ***report cards*** for all Government-approved biomedical devices, thus providing significant value to healthcare providers. An analogy can be drawn in that as it is a healthcare initiative, MEPR is as important as Customer Relations Management (CRM) because it is equivalent to an Equipment Relations Management (ERM).

MEPR is a term coined by the authors, to draw an analogy with its famous brother the Longitudinal Patient Record (LPR). The authors recognize that substantial work of several organizations in the area of biomedical device performance data warehousing and analysis, but MEPR goes one step further. It is not only a collector of equipment performance record, but it is a smart linker that builds the historical (temporal) records for the lifetime of each device. In the United States and Europe there are many trusted agencies that keep systematic records of the medical equipment. As an example, the Connecticut Hospital Association (CHA) in the state of Connecticut, USA www.chime.org has a unique database called CHIME that has been collecting temporal clinical patient data from Connecticut's acute care hospitals since 1980. The importance of CHIME comes from the systematic and consistent collection of patient clinical data in the chronological sequence per patient. CHA's Research and Education Department offers a "Toward Excellence in Care (TEIC)" program to discuss analyses and predictions derived from CHIME. MEPR can achieve similar success with the life-threatening biomedical devices.

3.0 OBJECTIVES OF MEPR

The objectives of the system are as follows:

1. To collect temporal ***"longitudinal"*** performance data of life-support biomedical equipment.
2. To serve as a focal point for collecting selected performance data for specific ***life-support*** biomedical devices.
3. To assist healthcare facilities in the standardization and retrieval of "as is" information on the reliability of the medical equipment.
4. To help hospitals in any legal dispute regarding the maintenance and the currency of medical equipment.

There are approximately 1,750 device classifications within sixteen medical specialties [3]. Out of the 1,750 classified devices:

76% are Class I: These devices are subject to the least regulatory control. They present minimal potential for harm to the user and are often simpler in design than Class II or Class III devices. Class I devices are subject to "General Controls", as are Class II and Class III devices.

12% are Class II: These devices are those, for which general controls alone are insufficient to assure safety and effectiveness. Existing methods aren't available to provide such assurances. In addition to complying with general controls, Class II devices are also subject to special controls. These special controls may include special labelling requirements, guidance documents, mandatory performance standards and post market surveillance.

12% are Class III: This is the most stringent regulatory category for devices. Class III devices are those for which insufficient information exists to assure safety and effectiveness solely through general or special controls. Devices classified into Class III are usually those, which support or sustain human life, are important in preventing impairment of human health, or present a potential, unreasonable risk of illness or injury.

The MEPR system, like the US TRW credit reporting system, shows all reported incidents for a particular biomedical device, throughout its lifetime. Like CRM, the analysis may reveal that a device may have been working well in another facility but may have not been properly maintained per instructions from the manufacturer. Figure 1 shows the organizations that will benefit from the MEPR. We refer to these organizations as the MEPR community.

Figure1: Information Sharing

MEPR is designed to produce the following benefits and capabilities:

- **Reported Incidents:** MEPR will offer an unbiased chronological profile of all the incidents involving a particular biomedical device. This "as is" information is reported by healthcare providers on routine basis and collected automatically by MEPR to other healthcare facilities on the performance of faulty devices.
- **Device Performance:** MEPR will report how devices perform under normal circumstances and during their lifecycle and show maintenance and technical support problems.
- **Device Status:** MEPR will report the status on devices that have been discontinued, removed due to problems, modified or upgraded.
- **Vendor Responsiveness:** MEPR will report how responsive vendors are to maintenance calls, how well they support their devices with new upgrades, improvements and other needed
- **Used Equipment for Sale:** MEPR can be tapped to offer significant information on the historical performance profile of used equipment. There's a hefty market for used (refurbished) biomedical equipment
- **Patient Complications:** MEPR will report patient incidents, complications or death due to malfunctions in the biomedical device.
- **Biomedical Device Procurement:** MEPR Repository would help during the procurement of new or similar devices or to learn more on the reliability of existing devices, the quality of design and vendor support.
- **Reported Research:** Research organizations are encouraged to send their findings and benchmarks to MEPR. This would be value added information to provide additional information about performance of a particular device.
- **Litigation Issues:** Hospital legal staff may resort to the historical record of a particular device in case of patient

complication, to determine the reliability and maintainability of the product. Similarly, patient's lawyer may investigate the records of the device and collect evidence.

- **IHA:** The International Hospital Association in the US and many other countries. The Hospital accreditation is based on meeting patient safety care giving environment, and equipment compliance. The Ministry of Health would definitely use the MEPR to support equipment acceptability process.

4.0 ARCHITECTURE OF MEPR

The MEPR system architecture consists of five interoperable components as illustrated in Figure-2:

- Authenticator
- Master Equipment Index (MEI)
- Warehouser
- Linker
- Data miner

The ***Authenticator*** is the security backbone of MEPR. Members and subscribers have to go through this checkpoint before they can use the system. All users are given a session number and the system tracks the entry and exit timestamps.

The ***Master Equipment Index*** (MEI) oversees and manages the creation of a unique index and manages the retrieval of the detail equipment records. MEI is akin to the Yellow pages for the MEPR system.

The ***Warehouser*** is the librarian of the system. It ensures that incoming raw data is clean, normalized before being assigned an index number and stored in the data warehouse as data objects.

The ***Linker*** is the component that checks the identity of the incoming records and stores the records in a longitudinal fashion by date and time. The linker acts as the kernel of the system validates the content of records with internal rules and metrics (encapsulated as business objects) and saves corollary and linkage information for further decision-making analyses.

The ***Data Miner*** generates documentary and analytical reports that meet the request of the users. The system provides a powerful data mining engine to help the user promptly locate the desired equipment before obtaining the results. Users can review the standard reports before requesting customized and complex queries. The ***Master Equipment Index*** (MEI) oversees and manages the creation of a unique index and manages the retrieval of the detail equipment records. MEI is akin to the Yellow pages for the MEPR system.

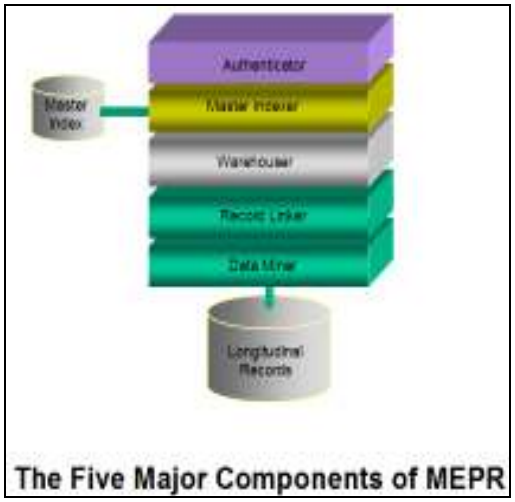

Figure -2: Components of MEPR

5.0 DESIGN OF MEPR

MEPR has two fundamental Functionalities:

Device Data collection Phase: MEPR receives raw data from healthcare providers device manufacturers. The providers send three types of information:

- Initial Device inventory
- Maintenance record of the devices
- Performance outcome (trouble reports) of any biomedical device.

The manufacturers send the technical information:

- Updated specifications
- Compliance data
- Benchmark results
- Repair data
- New and Obsolete Products

The facts reporting Phase: The second important responsibility of MEPR to report "As Is" information to users. No data will be modified or removed from records. The Data

Mining engine will parse all requests, fetch the required data, run the necessary procedure to generate the results and send them to the originator. MEPR will also keep track of the users; their type of requests, and powerful audit engine to make sure non-repudiation is active all the time. Other members of MEPR can send any information as long as it is related to a particular device and model and serial number. Figure-4 illustrates the information flow of the system.

Another powerful feature of MEPR is to be able to extract some compelling data points, and to synthesize ***a timeline for the life span*** diagram for any specific device. This is a proprietary feature will gather all the important milestones in colour and show them on the Graph. This visualization feature will tell the ***"untold story"*** of the disputed device. For example, the sudden recall and retirement of a monitor by a manufacturer is an indication of an engineering flaw or the result of many patient complications. This report card will also be crucial evidence in court as well as a supporting documentation for payers as well. Regardless of who wins or loses, the MEPR is always available to offer the facts.

4.0 DEVELOPMENT OF THE PROTOTYPE SYSTEM

The MEPR was built with Oracle 9. The prototype is designed with the following features:

- Scalable architecture: it can run on a small machine or a mainframe. It's all transparent to the user.
- Extensible architecture: It can be expanded and revised without difficulty.
- Open platform: it can run on multiple systems: Intel based Sun, IBM and even mainframe.
- Transparent Interoperability: the system can interface with mainframe in case the equipment data is on legacy systems
- The prototype will incorporate: Universal Web Services Standards endorsed by ISO, IEEE, OASIS: The exchange of data, documents, and voice will requires platform-agnostic standard-compliant technologies such as SOAP, JMS, XML, UDDI, WSDL voice.
- Web Services Orchestration to manage and coordinate the conversations among the Web Services, and to logically chain discrete functions into a cohesive process flow.
- Generate standard as well as Ad-Hoc reports and graphs through Data Mining.

6.0 DISCUSSION AND CONCLUSION

Industry experts at the Institute of Medicine (IOM) estimate that when a physician sees a patient, 70% of the physician's informational needs are unmet. The patient's medical record is either unavailable or incomplete. The big paradox is that healthcare opposes the systems, which are the most needed. The MEPR system is a case in point

Technologically, the MEPR system can easily be deployed as web-based, and accessed by subscribers or healthcare members. There are more complex global systems that process more transactions and burn more resources. The MEPR's biggest challenge is its "***cultural acceptability***". The TRW credit system is an operating necessity and has been accepted by financial institutions. MEPR has yet to prove itself as value-added to patient care.

The belief of the authors is that its acceptance will be driven by the efforts of healthcare providers to mitigate risks associated with life-sustaining devices. With time, MEPR will gain the trust of providers, payors, and other members of the MEPR community. MEPR can deliver value with the information it provides.

Prototyping MEPR with a group of users can demonstrate the value of device performance history and chronology. MEPR must incorporate the latest regulations (local and global) from healthcare, engineering, and safety before it becomes the authoritative knowledge source for biomedical devices. MEPR's success hinges on the discipline and commitment from providers and device manufacturers to populate the MEPR system with consistent and reliable data.

So far, this paper has described a simplistic prototype of the MEPR system. The project has demonstrated the viability of the system and its value in the patient care continuum. The Authors would like to see the prototype becomes a fully commercialized system, and is utilized by the healthcare community of the Kingdom.

Therefore, the authors would like to recommend the following steps:

- Get the approval and the sponsorship from the University and the Government to continue the collaborative effort between the University and the Ministry of Health, and build the first production system
- Connect the MEPR production system to a couple of selected hospitals, and measure the benefits of the system.
- Announce to manufacturers the launch of MEPR. Populating the MEPR with their current spec data will benefit them on the long run. The response of the manufacturers to support MEPR will indicate their willingness to stand behind their equipment.
- MEPR will be offered to hospital associations to help their members.
- MEPR is a service offered to subscribers and members only.
- MEPR will be offered to Medical Schools for training and education purposes.

REFERENCES

[1] WHO http: //www.who.int, Last access date: June 24, 2006

[2] Center for Disease Control and Prevention, http://www.cdc.gov, Last access date: June 24, 2006

[3] National Institute of Standards and Technology, http://www.nist.gov Last access date: June 24, 2006

[4] Food and Drug Administration, http://www.fda.gov, Last access date: June 24, 2006

[5] US Department of Agriculture, Food and Nutrition Service, www.ama.org, Last Access date: 24 June 2006

[6] American Hospital Association, http://www.aha.org , Last access date: June 24, 2006