Electronic Medical Record Systems for Developing Countries: Review

Nicholas A. Kalogriopoulos, Jonathan Baran, Amit J. Nimunkar and John G. Webster

***Abstract*—Countries around the world are in need of electronic medical record (EMR) systems that meet their specific needs. The developing countries need such systems. This paper describes briefly the benefits of EMRs in developing countries. It focuses on the basic EMR information, including types of EMRs, components of EMRs, and already existing EMRs, in order to establish which EMR systems would be feasible and effective for specific situations.**

I. INTRODUCTION

MEDICAL record keeping is undergoing a transition not only in the United States but also in developing countries. The developing world does not have a well-developed health care infrastructure against deadly diseases such as Human Immunodeficiency Virus (HIV) and Malaria among others, which leaves millions of helpless people in great need of medical assistance. It is estimated that greater than 95% of people affected by such diseases live in the developing countries. Devastating diseases like HIV require constant care and treatment in order to be held to a manageable level. In order for this care to be provided the basic paper-based medical record keeping is not sufficient and needs to be replaced by more efficient electronic medical records (EMRs) systems.

Paper-based record keeping has sufficed in the past, but now the 21st century calls for new, innovative systems. Throughout time paper-based systems have proven to become more and more inefficient and are continuously failing to meet the care provider's needs. With paper-based medical record keeping, communication between care providers is extremely difficult, especially in developing countries. In the United States, a paper-filed medical record may be scanned and sent to another care provider or sometimes faxed to wherever it needs to go. In the developing world, if a paper-filed medical record needed to be seen by a different care provider or someone at a different location, that paper file would have to be hand-delivered to this new location. This method is time-consuming and inefficient, along with the time it takes to conduct the tests. For example if a patient needs to get some kind of a test he or she needs to carry the paper record to the lab where the test would be administered, and then, these test results in form of the paper record would have to make its way all the way back to the doctor in order to be analyzed. So, it is quite obvious that paper-based medical record keeping does not meet the needs of an efficient health care model.

All of these efficiency problems that were previously discussed can be addressed by the implementation of electronic medical records (EMRs). Since electronic medical records can be sent from one location to another almost instantaneously, EMRs would practically eliminate the manual labor of transporting papers or even scanning or faxing papers if that technology were available. This, in turn, would save time and manpower and would decrease the time doctors and care providers take to communicate. This saved time could then be well spent for patient care, which would decrease waiting times for patients. The implementation of electronic medical record keeping would thus increase the overall quality of health care.

Electronic medical record systems have many benefits [1]. They would improve the legibility of clinical notes and provide decision support for drug ordering, including allergy warnings and drug incompatibilities. They also provide reminders to prescribe drugs and administer vaccines and warnings for abnormal lab results. Moreover, they help support program monitoring, including reporting outcomes, budgets, and supplies. They support clinical research and help with the management of chronic diseases such as diabetes, hypertension, and heart failure. Also, EMRs have been shown to be clinically cost-effective by inducing a net benefit of $86,400 per provider over a 5-year period [2].

Despite the many benefits of having EMRs in place, there are still several downsides, especially when systems are first implemented. EMRs can be quite difficult to establish and maintain in developing countries [3]. Many factors, including the population demographics, the location of the care center, and the availability of resources, such as electricity and internet, all come into play. Furthermore, some electronic medical record systems can be somewhat expensive to implement, which causes major problems for many developing countries. Also some physicians continue to resist the new technology, as they prefer the standard method of record keeping [3]. Many EMRs, however, have already been put into place and evaluated. Based on the evaluation of those systems, improved electronic medical

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N. A. Kalogriopoulos is a College of Engineering student at the University of Wisconsin-Madison 1550 Engineering Dr Madison, WI, USA 53706 (e-mail: nkalogriopou@wisc.edu@wisc.edu).

J. M. Baran is a Biomedical Engineering Masters candidate at the University of Wisconsin-Madison 1550 Engineering Dr Madison, WI, USA 53706 (e-mail: baran@wisc.edu).

A. J. Nimunkar is a Biomedical Engineering PhD candidate at the University of Wisconsin-Madison 1550 Engineering Dr Madison, WI, USA 53706 (e-mail: ajnimunkar@wisc.edu).

J. G. Webster is an Emertius Professor, Biomedical Engineering Department at the University of Wisconsin-Madison 1550 Engineering Dr Madison WI, USA 53706(e-mail: Webster@engr.wisc.edu).

record keeping systems have been developed and continue to be developed. This continues to decrease the expertise needed to establish and maintain the system and lower the health care costs.

II. TYPES OF ELECTRONIC MEDICAL RECORDS

A. Proprietary

Through the continued emphasis that is continually being placed on medical record keeping, proprietary medical record software packages continue to become introduced. Even as these may not be the best options for financially sensitive customers in developing countries, there are a number of free medical record keeping package currently available such as Google Health, Microsoft Healthvault, Revolutionhealth Health Records, and WebMD Personal Health Record [4].

B. Open Source Software

There is no one definition of open source software or an open source medical record keeping system because it varies from person to person as a result of slightly different interpretations and implementations. However, open source software can be described by its one main characteristic. The main requirement of open source software is that "*its source code must be freely available to anyone who wishes to examine it or change it for his or her own purposes*" [5]. This is crucial when it comes to medical record keeping systems because it allows for the system to be developed to each care provider's specific needs.

The first open source medical record keeping system was Veterans Health Information Systems and Technology Architecture (VistA) which was originally developed and maintained by the U.S. Department of Veterans Affairs (VA) [6]. Its design was intended to provide a high-quality medical care environment primarily for the country's military veterans. Not only did it meet its intentions but over time, it has proven capable of supporting a large variety of clinical settings and medical delivery systems. Many healthcare providers all around the world currently use this software. A major problem with VistA, however, is that the language used to implement it is the Massachusetts General Hospital Utility Multi-Programming System (MUMPS). MUMPS is not widely used and other languages are preferred, which would make modifications and enhancements to VistA extremely difficult [5].

Care2x is another generic open source medical record keeping system that began in 2002. It is web-based and has built upon other open-source projects. These projects include the Apache web server and the relational database management system MySQL. Care2x is known to be very feature rich and can be configured to many clinical structures. There are, though, some problems with Care2x, as well. The purpose of these systems is to provide the greatest quality medical care through the use of efficient electronic medical record keeping. Care2x failed to meet this purpose with its lack of structured documentation, unorganized code, and poor naming conventions [5].

After several years of evaluation and development, open source medical record systems have come a long way. One of the most recent and promising open source EMRs is the OpenMRS [7]. It was formed in 2004 as an open source medical record system framework for developing countries. OpenMRS is an application that allows for the design of a customized medical records system specific to the care provider's needs with no programming knowledge. However, one needs to possess medical and systems analysis knowledge. This system is based on a conceptual table structure. This structure is independent of the types of medical information to be collected or the forms to be used. This is very beneficial because it can be customized for different user needs. A concept dictionary, which stores all diagnosis, tests, procedures, drugs, and other general questions and potential answers, was created as the core of OpenMRS on the basis of the principle that information should be stored so it is easy to summarize and analyze. The conceptual dictionary allows minimal use of free text and maximum use of coded information.

Another major benefit of OpenMRS is that it is free. All of its components and all the resources needed are available for download and are freely available. The only component that is not free is a currently used plug-in, which utilizes Microsoft's InfoPath program for data entry. This does require a license but is nonetheless a relatively small barrier to overcome. Because of its low cost, being essentially free, many developing countries have begun to implement OpenMRS. Some nations that are currently using OpenMRS include Kenya, Rwanda, South Africa, Uganda, Tanzania, Zimbabwe, Lesotho, Malawi, Peru, and Haiti [8].

III. EXISTING EMRs IN DEVELOPING COUNTRIES

Even as the developed countries are leading the electric record revolution they are struggling to adapt to the new system, and at the current time only 9% percent of hospitals in the United States have adopted electronic medical record keeping [9]. This figure is in stark contrast to the 60% of Indian Hospitals which are using electronic medical record keeping in their surgery rooms [10].

In Kenya in 2001, the Mosoriot Medical Record System (MMRS) was developed. The project name was later changed to AMRS. The system serves 60,000 patients, and runs Microsoft Access on two networked computers. These are powered by an Uninterruptable Power Supply (UPS) and backed up with a solar battery. Patients register in the system on their arrival to the clinic and travel through the clinic with a paper visit form. In comparison with the clinic before and after the system was implemented, there were great improvements. Patients visits were 22% shorter, provider time per patient was reduced by 58%, patients spent 38% less time waiting in the clinic, clinic personnel spent 50% less time interacting with patients, 67% less time interacting with each other, and more time in personal activities. The downside is that clerks must perform the

registration and transcribe visit data, which is prone to errors [11].

In 1996, Partners In Health (PIH) started an open source web system in Peru that was backed by an Oracle database. The system serves 4300 patients. Physicians fill out forms, and nurses and their assistants enter medication data. The medication order entry system has shown 17.4% fewer errors than the previous paper approach. Drug requirements analysis tools that are based on the medications prescribed matched the usage data in the pharmacy to within 3%. This EMR demonstrates the strength and flexibility of a web-based approach. But, of course this requires a reliable internet connection [11].

In 1999, PIH began an EMR system in parts of rural Haiti. These rural areas have virtually no roads, electricity, or telephone service. This design serves 4000 patients and is the same design that was established in Peru except with an additional offline client for data entry and review. This offline component helped overcome unreliable internet communications. When the network is down, the offline component still allows data entry and case viewing. This system displays how EMR systems can overcome great challenges in remote areas with virtually no infrastructure and limited technical expertise. Other EMR systems include a Careware system in Uganda that is a stand-alone database built with Microsoft Access and an EMR in Malawi that is a touch screen patient management information system. The downside of the system in Malawi is that it is difficult to enter free text with the use of touch screens [11].

IV. STRUCTURE OF SYSTEMS

A. Data Model

The data model is the design of the database tables and the relationships between them. The design of the database is primarily determined by the functional requirements of the EMR system. Simple single function systems will probably benefit from "flat file" database designs. "Flat file" database designs are spreadsheet-like. They consist of single rows and columns for data items. They are very quick and simple to create for small systems, but their weaknesses are that they are inflexible and difficult to scale. As the system grows and must provide for a larger population, adding new data items requires changing the entire structure of tables in the database and scaling to hundreds or thousands of people becomes nearly impossible [11].

Multifunctional systems need to be able to do many things and support a variety of functions. They need to be able to handle different types of data, be able to evolve as the system continues to grow, be able to allow for data to be exported in standard formats, and be able to support different languages and variations in medical terminology. Because of these needs, multifunctional systems would most likely find greater benefit in coded database designs. In coded database designs, adding a new data item just requires typing in a new type of observation. This allows the database to evolve during the lifespan of the system. Furthermore, it is straightforward to link to standard medical coding systems, it simplifies support for multiple languages, and it scales very well, which makes it ideal for large EMR systems [11].

B. Networks

There are three types of networks that can be utilized in EMRs; these include stand-alone systems, local area network systems, and wide area network systems. Stand-alone systems are databases and user interfaces that are deployed on a single machine. They have no explicit functionality to communicate with other machines over a network. They are, though, the easiest to design, implement, and maintain, which makes them suitable for small EMRs. Local area network systems are deployed at a single site, and the machines at the site have a relatively fast connection to each other. Users have local client application interfaces in which they communicate directly on the central database [11].

Wide area network systems are deployed across multiple geographical sites. They can be deployed across a city, state, country, or multiple countries. There are three categories of wide area network systems: thin client, thick client, and hybrid. Thin client wide area network systems revolve around a single, central high-powered server with a single database. No client application is required at remote machines. For this type of network system, web browsers are generally used; however, functionality is possible with Citrix Winframe, Microsoft Infopath, and Windows Terminal Server, but at a price. Proprietary software does not need to be installed, but a reliable network connection must be available [11].

Thick client wide area network systems are quite the opposite of thin client systems. They store and maintain local data by hosting a database locally. In some cases, large multi-user database systems can be installed at each site. This multi-user database would provide faster and more comprehensive services than a basic web-based system, and it continues to function if the internet is unavailable. Communication between sites can be via web protocols, direct database synchronization, or various proprietary protocols. The downside to thick client systems is that complex databases are difficult to maintain in remote areas [11].

In many ways, the hybrid approach for wide area network systems is the best option. A program is installed on a remote machine that uses a local web-based interface to store data locally, and it uploads these data to the central server when the network is available. When the network is unavailable, local storage is used. Nonetheless, every system has its pros and cons. For the hybrid approach, data synchronization becomes an issue if two users modify or upload the same record simultaneously [11].

The benefits of using networked EMRs are many in comparison to other systems. Data are accessible and shared at multiple sites, and users can enter data simultaneously. Moreover, data can be backed up automatically at more than

one site, and information can be readily communicated between multiple locations. Wide area network systems can link up remote locations, and remote sites can be upgraded over the internet if a web-based system is in place [11].

V. Applications of Medical Record Keeping

As electronic medical record keeping platforms continue to show promise as the future of the field technology is beginning to grow around these platforms. Examples of this include the Mobile Care (Moca) Platform developed by a team at MIT [12]. This platform uses mobile cellular phone (Google Android) communication to send data which easily integrates into OpenMRS. Once the data is localized remote doctors can diagnosis problems and send the results to the mobile handheld. Integration of medical diagnostics and medical record keeping software hold the promise of simplifying the process of medical data collections.

As electronic medical record keeping continues to proliferate the telemedicine applications will continue to expand giving the possibility of providing medical care to individuals across the globe. These telemedicine applications in these low resource settings may serve as the only means to reliably obtained healthcare [13] [14].

VI. DISCUSSION

When choosing which electronic medical record system to implement, one should consider the following factors: population, location, and availability of resources. If the population the EMR is to serve is small, one should consider "flat file" databases and possibly stand-alone systems. If the population the EMR is to serve is large, one should think about coded databases and different networked systems. If the EMR is to serve remote areas, that fact should be taken into consideration; extra thought should go into the availability of resources at that remote site. If electricity, phone service, and the internet are not available, the EMR implemented for those sites should be able to overcome those challenges [11].

To move beyond successful prototypes to widespread use, it is essential that EMR systems are developed with open standards and sharable components. A common data model can efficiently link the wide range of technology platforms discussed earlier and ease collaboration between projects [11]. The fact is that different EMRs are more beneficial in different locations than others. Nonetheless, electronic medical record systems should be implemented with the future in mind. It will one day be beneficial to society to link all EMR systems together. This can be done quite easily and efficiently if society takes steps towards that now by implementing EMR systems that have a common structure and framework. For this purpose, open source EMRs seem to be a viable solution for the present and the future. It seems that OpenMRS has the most potential and is the fasting growing open source system available today. Because it has common framework and is almost completely comprised of free, open source components, OpenMRS may be the best choice for today's EMR.

VII. CONCLUSION

No matter what electronic medical record system is implemented, it is a sure thing that the overall quality of healthcare in the area will increase. EMR systems will eliminate problems, eliminate errors, save time, and save money in the long run. With further research, evaluation, and development, EMR systems will continue to get easier to implement and as a whole cheaper to establish and maintain. EMR systems are a must for developing and developed countries alike.

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