



Towards the Application of Open Source Software in Developing National Electronic Health Record- Narrative Review Article

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Abstract

Electronic Health Record (EHR) is a repository of patient health information shared among multiple authorized users. As a modern method of storing and processing health information, it is a solution for improving quality, safety and efficiency of patient care and health system. However, establishment of EHR requires a significant investment of time and money. While many of healthcare providers have very limited capital, application of open source software would be considered as a solution in developing national electronic health record especially in countries with low income. The evidence showed that financial limitation is one of the obstacles to implement electronic health records in developing countries. Therefore, establishment of an open source EHR system capable of modifications according to the national requirements seems to be inevitable in Iran. The present study identifies the impact of application of open source software in developing national electronic health record in Iran.

Keywords: Electronic Health Record, Open Source Software, Health Information System, Iran

Introduction

The most important goal of health systems is improving quality, effectiveness and efficiency of healthcare services (1). Healthcare is highly dependent on information. However, scattered health information has a negative effect on healthcare services and would impose more expenses to the healthcare system (2). Electronic Health Record (EHR) as a modern method of storing and processing health information is a solution for improving quality, safety and efficiency of patient care and health system. The basis of EHR is clinical information; however, it is used not only by clinicians, but also by those who manage healthcare operations, quality, risk, research, education and payment. Even, patients can access

to their health information through EHR (3). There is no general agreement on a standard definition for electronic health record. However, ISO/TR 20514 defined it as "a repository of information regarding the health status of a subject of care in computer processable form, stored and transmitted securely, and accessible by multiple authorized users. It has a standardized or commonly agreed logical information model which is independent of EHR systems. "Its primary purpose is the support of continuing, efficient and quality integrated healthcare and it contains information which is retrospective, concurrent, and prospective" (4). The benefits of EHR have been examined by considering clinical, organizational,

and social outcomes. Clinical outcomes address the quality of care and reduction of medical errors. Organizational outcomes include financial and operational performance. However, social outcomes include more ability for conducting research and improving population health (5). EHR is not limited to a single location. It has the potential for a national health information infrastructure. It should even be capable of integrating data across providers and from personal medical records to form a longitudinal health record. However, EHR requires a significant investment of time and money, while many of healthcare providers have very limited access to capital. That is why the cost benefit issue and the application of open source software (OSS) have been taken into consideration in some EHR projects (3). The present study identifies the potential impact of application of open source software in developing national electronic health record in Iran.

Open source information systems in healthcare

"Open Source Software" (OSS), "Free and Open Source Software" (FOSS) and "Free, Libre and Open Source Software" (FLOSS) - although are not exactly the same- are alternative terms to describe free software (6). Open source does not just mean access to the source code. There are basic principles for open source software including free redistribution, inclusion of source code, allowing for modification, integrity of the author's source code, no discrimination against any person or group, no discrimination against fields of usage, no need for an additional license. Also the license should not be specific to a product or technology and should not restrict other software (7). The promise of Open Source Software is better quality, higher reliability, more flexibility, lower cost, and an end to predatory vendor lock-in. It harnesses the power of distributed peer review and transparency of process (8). Open source technology is one of the most effective mechanisms for technology transfer which could foster the national economy. This is because the source codes and licensing of the software are free of charge and open for

inspection and usage (9). Today, a wide range of open source applications is accessible through the web including web servers, web browsers, databases, programming languages, image editors and email clients (10-15). Open source applications have been also utilized in healthcare. OSS could provide competition in commercial market, encourage innovation and promote compatibility and interoperation in health domain. This would guarantee better quality and lower cost. Also it would make the systems more responsive to changing clinical and organizational requirements (16). Several communities work on developing open source EHR systems to reduce the costs of EHR deployment and maintenance (17). In America, many systems deployed by the U.S. government use free and open source software (18). Nowadays, a large number of health information systems are available as open source Evidence based Guideline and Decision Support System (EGADSS) is an open source Clinical Decision Support System (CDSS) project began in May 2004 to provide patient specific point of care reminders. EGADSS would respond to requests from electronic medical records to provide patient specific clinical guidance based on its internal guidelines. One of the core EGADSS components is the Guideline Reasoning Engine. It operates on decision algorithms, medical knowledge, and specific patient data to generate recommendations and guidance for clinicians in order to aid them provide high quality care (19). Care2X is a hospital information system through which the authorized staff like physicians can access patients' data even from outside the hospital without using specialized software. All major components of Care2X are free (20). Open Source Cluster Application Resources (OSCAR) is open source Electronic Medical Record (EMR) which was started by the Department of Family Medicine at McMaster University In 2001. It contains healthcare information with a lot of functions including complete scheduling, e-charting, prescribing, billing, lab downloads, tables and graphs, chronic disease management tools, disease registry, automated customizable forms, sophisticated antenatal care record and planner,

tabulation of outstanding preventative and intervention practices, and also research tools. OSCAR is used by healthcare professionals including physicians, nurses, midwives, social workers, psychologists and physiotherapists (21). The "Open Source EHR" project directed by the American Academy of Family Physicians (AAFP) is an attempt to lower the cost of EHR by sharing the source code (3). Another example is ORCA (Open Receipt Computer Advanced) which is a project of information and communication infra-structure based on OSS to overcome problems of high costs, inflexibility and restrictions associated with proprietary systems. About 14,000 medical providers in Japan are using products of ORCA (22).

Application of OSS in national health systems has been welcomed by many countries. Open source software has the potential for improving healthcare. The advantages of an open source EHR outweigh the costs of a proprietary EHR system (23). Open source technology makes the opportunity for advanced innovation in the health information sector of low income countries (24).

Health information systems in Iran

In Iran several scattered attempts to design health information systems software has been made so far. These systems were produced by different companies and applied in different regions. As they did not follow particular standards, integrating their outputs is not possible (25). However, development of a set of standards is always a necessary requirement for integrating different information systems (26). In Iran, several studies on medical information systems have been done focusing on various domains especially on usability, efficacy, standards, architecture, structure and content.

In 2001, the usability of software packages in Medical Records Departments of several hospitals in Tehran was compared. The findings showed that the overall usability of medical records software packages in the hospitals was 55% which indicated the available packages did not have the necessary capabilities to meet the requirements of medical records departments (27). In another study nine hospital information systems applied in

a number of hospitals in Iran were evaluated based on the general requirements of Hospital Information System (HIS). The results showed that total average of compatibility of systems with the general requirements of HIS was 65.4%, (28). In 2006, an object-oriented model for some key messages was designed to support EHR through comparing weaknesses and strengths of HL7 and openEHR standards. According to the study, OpenEHR have had a significant influence on the development of EHR standards. It could ensure open, future-oriented Electronic Health Records in Iran (29). In 2007, EHR content, structure, and terminology standards in selected organizations were investigated in order to design an appropriate model of EHR for Iran. The study suggested a national model for EHR based on the weakness and capabilities of standards provided by the investigated organizations (2). According to the evidences, a wide range of information systems are used in Iranian hospitals, clinics, pharmacies and offices. However, the majority of these systems are originally designed as non-shareable. To design an integrated EHR system, all components of the health system should be engaged through an organized shareable information system. Therefore, the available clinical data on the existing systems in Iran have neither been applied in decision making nor served as a basis for evidence based medicine. This situation addresses the need for developing an integrated shareable information system of EHR in Iran. Such a system will not only help using the collected data for different purposes, but also serves as an infrastructure for a variety of e-health activities in the country (25). The evidences also showed that financial limitation is one of the obstacles to implement electronic health records in developing countries. Therefore, establishment of an open source EHR system capable of modifications according to the national requirements seems to be inevitable in Iran.

Iranian electronic health record

Establishment of a national EHR requires a wide cooperation and coordination among involved ministries and organizations. The prerequisites for a national EHR can be summarized as follows:

1. Electronic record in a national extent including Health Data Center
2. Facilities for electronic recording and transferring information produced in Health Data Centers including hardware and software equipments and also cultural infrastructures
3. Developing standards for coding and data exchange
4. Development of information technology infrastructures with sufficient band-width and connections to meet the present and future needs of national health system
5. Development plan for communication and messaging services to support new information cycles (25).

The project of Iranian electronic health record (SEPAS) supported by Iranian ministry of health is the greatest information technology project in the health sector in the country. At the present time, the infrastructure of SEPAS is being processed to provide a platform for data exchange among health centers all over the country. Health information of all citizens from birth to death will be recorded in their individual EHRs. As a result, the medical history of each patient will be retrievable by authorized health centers. The key values of SEPAS include providing citizen rights, justice, data confidentiality and information security. The main objectives of this project are:

- Integration of Citizens Health Information;
- Improving the quality of health services;
- Equitable distribution of health resources;
- Improving the management of health resources and improving healthcare system based on quick access to correct and accurate information;
- Expediting and facilitating production and management of biomedical knowledge;
- Contribution to the development of evidence based medicine;
- Reducing complications resulted from medical errors;
- Reducing healthcare costs;
- Increasing security of health information;
- Strengthening the monitoring role of the health system;

- Improving the quality of medical education;
- Providing new electronic services;
- Improving the industry of healthcare in Iran (30).

According to the architecture plan for national EHR in Iran, information systems would be categorized in three levels which are peripheral, intermediate and central. These systems are independent and connected to one another via certain standard protocols. As a result, information would flow upwards through the following levels and circulate throughout the whole network:

1. Information system level 1 (peripheral level) which is connected to medical equipments or portable devices such as smart cards or PDAs. This kind of information system can not necessarily be integrated with the national level. It can simply be used at intermediate health providing centers for the ease of data entry and transfer.
2. Information system level 2 (intermediate level) which is installed and utilized in health providing centers. Such systems are customized according to the needs and specification of healthcare providing centers.
3. Information system level 3 (central level) which will be installed at the ministry of health and medical universities. Information systems at this level serve as the infrastructure of the whole network. They are necessary for compiling, and transferring of information at a national level.

Development of Electronic Health Record in Iran would increase:

- public access to healthcare services especially in deprived regions and evenly distribution of healthcare services throughout the country;
- modification of the national health management system based on the evidence and precise data;
- utilization of healthcare resources;

- delivery of modern electronic services such as teleappointing, teleconsulting, reminder and alerting systems;
- provision of a proper background for production and management of medical knowledge;
- supervision, evaluation and audition of healthcare services;
- establishment of statistical registry system;
- community cooperation in public health;
- individual accessibility to personal health information to choose the appropriate method of diagnosis and treatment;
- provision of necessary tools for clinical decision making;
- The work flow of the whole system through reengineering the process and performance of different units;
- the income cycle;
- citizens` satisfaction;
- quality of care through developing a standard method for collection and interpretation of data;
- time and cost effectiveness and efficiency;
- medical knowledge by creating a suitable structure for retrospective as well as prospective medical researches;
- documentation and audition of documents;
- following the medical guidelines through sending alerts by the system;
- management of health centers;
- And the accessibility of medical information in cases of crisis and natural disasters.

On the other hand, developing Electronic Health Record in Iran could decrease:

- medical errors and the consequent complications;
- mortality rate caused by medical errors;
- drug adverse effects through recording individuals previous reactions;

- need for more human resources especially in accounting and medical records departments;
- cost of healthcare by cutting repeated or unnecessary services;
- cost of stationary materials e.g. paper charts and radiology films and fixed expenses for equipments;
- accounting, documentation and archiving expenses;
- required time for retrieving and analyzing medical data;
- waiting time for admission;
- Hospitalization time (31).

Open source solution for developing Iranian EHR

Open source technology is one of the most effective mechanisms for technology transfer which could foster the national economy. This is because the source codes and licensing of the software are free of charge and open for inspection and usage (9). Many organizations and countries face various problems in using proprietary software which could be resolved through using OSS. Among them, the cost of licensing, the difficulty of choosing a system capable of being modified according to the changing needs with the ability to integrate with the existing and future systems are major barriers (22).

Open source solution provides many potential benefits for the establishment of national EHR in Iran. It allows quick implementation of the tools, while reducing medical errors and costs in a fast and easy process (32). The advantages of utilizing OSS in developing national EHR include high quality, reliability and security of system resulting from continuous and extensive peer review of software; availability of source code which enables any modification in response to the changing missions and threats; avoidance of vendor lock-in; freedom to use; and low total cost of ownership (18).

The approach of open source is similar to the peer-review scientific process through which one can see and reproduce results to understand and promote what is already shared (33). In healthcare

systems, continuous and broad peer review of source code could make the system secure and reliable. This will improve data confidentiality and will also be useful for quality assessment (34, 35). Evaluation of health information system would improve the performance of the system (36).

At present time, developing countries are well-positioned to take advantage of the open-source movement especially in health sector to overcome health inequity (37). Open source software would create a mutually beneficial relationship between vendor and customer while proprietary software generally lacks this characteristic. Open source is a collaborative process that is improved by the coordinated sharing of information (38). In other words, cooperative development of high quality software is one of the main advantages of open source approach. Well-designed open source software could enable other developers to adopt and modify the software according to their requirements. Finally, they can build their own tools based on the contribution of other expert's experiences (39).

Millard and colleagues believe that “*a new Millennium Development Goal should include the creation of a universal open-source health informatics platform that will allow the collection, management and delivery of clinical and population data that will guide decision processes at the local, regional and global levels*”(40). By using open source systems, institutions are not locked in to specific vendors and have more control over the application's features. Some believe that the reduced total cost of ownership is the major benefit of OSS (35). However, this is highly dependent on the financial situations of the country and its total income. For a developing country like Iran, the application of OSS in the establishment of national EHR and other health information systems would create a great opportunity to improve national healthcare setting without paying major costs for development and maintenance of health information systems.

Conclusion

As most developing countries like Iran suffer from insufficient financial resources to purchase

and support EHR commercial software, the application of open source EHR with the ability to be customized based on the national needs seems inevitable.

Ethical considerations

Ethical issues (Including plagiarism, Informed Consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

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