



## Evaluation of Health Level Seven (HL7) Standards Implementation in Egyptian Hospitals

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### Authors' contributions

*This work was carried out in collaboration between all authors. Author RHF designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript and managed literature searches. Authors ASE, MM and RHF managed the analyses of the study and literature searches. All authors read and approved the final manuscript.*

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### ABSTRACT

Health information technology has entered the everyday workflow in a variety of healthcare providers with a certain degree of independence. This independence may be the cause of difficulty in interoperability and integration for shared Electronic Health Records (EHRs) which was overcome by a number of interoperability standards. Health Level Seven (HL7) is a standard for the interchange of data within the healthcare industry. Although the benefits of adopting HL7 are well known, only a few hospitals in Egypt have actually implemented it. This paper investigates the barriers and success factors of the three perspectives (environmental, managerial and technological) affecting positively and negatively on the implementation of HL7 standards in the Egyptian hospitals, and it presents recommendations which can be used by academics and

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practitioners to develop the implementation of HL7 standards. For the purpose of this study a questionnaire was developed and applied on the senior managers and decision makers of the information system in a sample of Egyptian hospitals. The study revealed that HL7 was implemented only in 18% of hospitals sample. Also, it identified the most important barriers facing the dissemination of HL7 implementation in healthcare sectors in Egypt which are unavailability of financing, lack of competition toward health data exchange, and low awareness of HL7 and its importance.

*Keywords: Health Level Seven (HL7); Electronic Health Records (EHR).*

## 1. INTRODUCTION

Health Level Seven (HL7) is one of the most well-known standards for electronic data exchange within the healthcare industry. Its primary goal is to simplify communication interfaces and allow interoperability among heterogeneous healthcare applications. HL7 standards enable semantic interoperability across all platforms for the exchange, integration, sharing, and retrieval of electronic health information. These standards define how information is packaged and communicated from one party to another, setting the language, structure and data types required for seamless integration between systems [1,2]. Also HL7 and Digital Imaging and Communications in Medicine (DICOM) should be adopted in the medical information exchange in order to reduce the complexity of interface design, and to facilitate information exchange among various healthcare information systems [3].

European countries have made substantial progress towards modern e-Health infrastructures and implementations, with an action plan to "focus on deploying e-Health systems, setting targets for interoperability and the use of electronic health records (EHR)" [4], and European communities have contributed to the success of HL7 through its productivity, innovation, and global leadership [5]. In the United States, even though HL7 utilization rate is very high, the standard had still not been adopted universally by hospitals [3].

On the other hand, developing countries are reported to have a large amount of unreliable health data, paucity of human resources, and poor information technology infrastructure. Therefore, effective Health Information Systems (HIS) are needed to improve the processes of data handling in order to extract useful information for health planning, decision making, and resource allocation [6].

At the Arabian level; Due to the lack of national action regarding the adoption of health data standards [7], little is known of healthcare organizations and hospitals in Egypt, the Gulf States, Oman and Saudi Arabia that are using HL7 standards. Vendors are implementing it, yet there is no affiliate organization. HL7 may have to play the role of catalyst to help establish an "HL7 Middle East" (e.g. located in Dubai or Oman) [8].

HL7 standards are implemented in a few number of hospitals in Egypt even though the current status of EHR adoption in Egypt has fallen away from the desired [9]. This paper evaluates the implementation of HL7 standards in Egyptian hospitals, highlighting obstacles that prevent hospitals to implement HL7, and the success factors which help hospitals to implement it taking into consideration the environmental, managerial and technological factors.

## 2. THE EGYPTIAN HEALTH CARE SYSTEM

Egypt is a developing African country, with a population of about 87.5 million and a land mass of about one million km<sup>2</sup>. The life expectancy is 71.8 years [10]. Health expenditure is 4.66% of the gross domestic product (GDP). The general government expenditure on health relative to the total percentage expenditure on health is 39% [11].

Healthcare sector in Egypt is divided into two main categories which are the public and the private sectors. The public sector includes the Ministry of Health, university hospitals which are controlled by universities and the third type is the health insurance hospitals which are controlled by the General Authority for Health Insurance under the supervision of the ministry of health [12]. The private sector is divided into three types; hospitals, medical centers and doctors clinics. There are 622 public hospitals and 920

private hospitals most of them in Cairo [13]. The state is keen on extending health insurance coverage to include non-insured new categories of people.

Healthcare sector is suffering from many of the challenges, due to lower government expenditure on health over many years, that leads to the citizens bearing about 72% of the total health expenditure as out-of-pocket expenses, resulting in reduced quality of life, preventive services and safety, as well as the negative impact on the equality of access to health services [14].

Recently there was an effort to unify and update various information systems of the Ministry of Health and National Population bodies, National Health Information System (HIS) was designed to cover all preventive, curative and primary healthcare sectors to support the decision-maker in the field of health to decide what is the best and the most effective action in the field of health [15]. But the system is poorly integrated and has limitations in interoperability because of lack of national plan to adopt health data standards.

### 3. HEALTH LEVEL SEVEN STANDARDS

Health Level Seven (HL7) is an application protocol for electronic data exchange in health care environments. It was produced by HL7 international which is an ANSI accredited not-for-profit Standards Developing Organization (SDO). It has affiliates in 32 countries since its foundation in 1987 to produce a standard for hospital information systems [16]. "Level Seven" refers to the seventh level of the International Organization for Standardization (ISO) seven-layer communications model for Open Systems Interconnection (OSI)- the application level [1].

The current status of health data standards in many developing countries is still vague [7], so it should be obvious that an integrated health information infrastructure is important and that such infrastructure needs to be based on standards for information sharing and exchange between information systems, programs, and institutions [17].

### 4. OBJECTIVES OF THE STUDY

Shedding light on a developing country like Egypt explaining what the status of HL7 standards implementation. Clarifying the success factors and challenges affecting on HL7 standards implementation in the Egyptian hospitals.

## 5. RESEARCH METHODOLOGY

A descriptive quantitative method was employed in order to study this case closely. A questionnaire was developed and administered to senior managers and decision makers of the information system in a sample of Egyptian hospitals. Clarifying the status and the factors of the three perspectives (environmental, managerial and technological) affecting positively and negatively on the implementation of HL7.

### 5.1 Scope of the Study

This research limited the study scope on:

- (1) **Spatial scope:** The researcher designed a plan to cover all hospital types from Cairo because:
  - It contains the largest number of hospitals, so the sample represented the study population.
  - It contains different types and sizes of hospitals.
  - It is easy in movement.
- (2) **Temporal scope:** The questionnaire was applied within September and October 2014.
- (3) **Objective scope:** The questionnaire focused on a combination of dependent factors with three dimensions (environmental- managerial and technological) and how they related with hospital category and hospital capacity as independent factors.

### 5.2 Study Tool: Questionnaire

Questionnaire is the data gathering technique used in surveying and evaluating HL7 standards adoption in Egypt. The questionnaire is divided according to the case of hospitals firstly if they use EHR or not, secondly if they use EHR based on HL7 standards. The questionnaire used here was designed through a standards number of steps as given in [18-21]

- a- **Initial Planning and Designing:** According to the study objectives; each information was obtained from questions answers should achieve a goal of the objectives of the study. The information is collected from a closed ended questions with a predefined answers that chosen by

the respondent. In this step discussing the research problem with colleagues and subject matter experts is critical to developing good questions. then selecting a pilot sample of hospitals and noting all respondents' remarks.

- b- Pre-Testing the Questionnaire:** Pre-testing the questionnaire is an essential step before its completion. The purpose of the pretest is to check question wording, and to determine if the research questions are appropriate, to reformulate or eliminate ambiguous or superfluous questions, to determine whether the questionnaire is balanced in its structure, and to discover whether instructions were properly followed.
- c- Final version of the questionnaire:** In this step the focus is on configure the final image of the questionnaire based on the amendments and changes that were in the previous step.

### 5.3 Validity and Reliability

Validity concerns the degree to which a question measures the quantity or concept that is supposed to be measured. And reliability concerns the consistency of a measure [18]. Reliability of the questionnaire has been verified through calculation of "Alpha-Cronbach equation" for questionnaire to assess the reality of HL7 implementation for exchange and integration of health data in hospitals. It was found that the value of this coefficient ranged between 0.71-0.90, which refers to the values of stability of the questionnaire with a high degree, the following table (1) illustrates this:

**Table 1. The stability coefficient of a questionnaire aspect to assess the reality of HL7 standards implementation in Egyptian hospitals**

Questionnaire aspect	$\alpha$ coefficient
1- obstacles you faces to implement electronic health record based on HL7 standards	0.71 **
2- Why there is no intention to use an Electronic Health Record system (EHR) program	0.83 **
3- Success factors that helped in the implementation of HL7 standards in the hospital	0.90 **

\*\* Indicates that the value of the reliability coefficient is statistically significant at the level of (0.01)

### 5.4 Study Community and Sample

Gathering data from all hospitals in Egypt was not possible for this research, therefore an appropriate sampling procedure was chosen. "A sample is a portion or subset of a larger group called a population" [22]. Sampling procedures can either be probability or non-probability. Typical techniques for probability samples are simpler random sampling, systematic sampling, stratified sampling, and cluster sampling [23].

**Table 2. Sample description**

Categories	Frequency	Percentage (%)
<b>Career position</b>		
Hospital Manager	0	0
Senior manager.	9	18.36
Manager of information center	18	36.74
Quality manager.	4	8.16
Specialist in medical records	18	36.74
<b>Hospital type</b>		
Governmental Hospital.	16	32.65
University Hospital.	6	12.25
Health insurance.	4	8.16
Private Hospital.	16	32.65
Charity Hospital	7	14.29
<b>Hospital size</b>		
Major (a capacity of 600 to 1000 beds).	13	26.53
Central (a capacity of 150 to 600 beds).	18	36.74
Regional (accommodate 50 to 150 beds).	13	26.53
Medical Center (accommodate about 50 beds).	5	10.20

For this study the cluster sampling was chosen because the studied population is spread as a clusters across a wide area. By distributing the research questionnaire on a group of managers and decision makers in a sample of 75 accredited hospitals and 26 were not answered. The valid response rate was 65.3% (49) hospitals. Table (2) above shows the description of the study sample.

## 5.5 Research Hypotheses

All the hypotheses that have been tested in this study are alternative hypotheses; Hypothesis testing was carried out to know if:

1. There is a statistically significant difference between hospital category and the barriers toward HL7 implementation.
2. There is a statistically significant difference between hospital capacity and the barriers toward HL7 implementation.
3. There is a statistically significant difference between hospital category and the success factors toward HL7 implementation.
4. There is a statistically significant difference between hospital capacity and the success factors toward HL7 implementation.

## 6. RESULTS

In this study, a 3- point Likert scale (agree-neutral- disagree) used. The profile of the majority of the respondents revealed that 13 (26.53%) hospitals use EHR and 36 (73.47%) didn't use EHR. These two groups will be divided later according to intention to adopt EHR and HL7 standards; hospitals adoption status was divided into five cases as follows (Fig. 1):

1. The hospital does not use EHR but intend to implement it based on HL7 standards.
2. The hospital does not use EHR and does not intend to use it.
3. The hospital uses EHR based on HL7 standards.
4. The hospital uses EHR which is not based on HL7 standards and intend to implement it.
5. The hospital uses EHR which is not based on HL7 and do not intend to implement HL7.

The missed case of hospitals which do not use EHR but there is intention to implement it without HL7 did not appear in the pilot test and in the field study.

### 6.1 Analysis of [Case 1]: Obstacles Delay HL7 Adoption

The case of hospitals that intend to adopt integrated EHR system [case 1] many obstacles that delay these plans. A total of 26 (100%) of the hopeful hospitals need to get an integrated EHR system, 9 (34.6%) of them have the plan to

adopt it within 1 year, 7 (27%) of them intent to adopt it within 2 years and 10 (38.4%) of them think that the plans will achieved within 3 years. But there are (environmental- managerial- technological) obstacles militating against the achievement of these aspirations. The agreement ratio between study sample toward this obstacles ranged between (7.7- 57.6%). For the environmental dimension the highest rates of agreement between the study sample with ratio (57.6%), to the unavailability of financing followed by (38.5%) to lack of competition toward health data exchange and Lack of supervision and quality evaluation. For the managerial dimension, the highest rates of agreement between the study samples with ratio (34.7%), to Lack of long-term vision for the future to adoption of HL7 standards followed by ratio (30.9%), to Lack of experts to activate integrated HIS in the hospital. Finally for the technological dimension, the highest rates of agreement between the study sample with ratio (46.2%), to the hospital have complicated information system and ratio (22.9%), to weak technological efficiency of administration staff and difficulties in systems automation (Fig. 2). The remaining items get a medium agreement ratio. After field study the respondents add barriers as:

- Hospital may follow a general secretariat, in this case it cannot take independent decision to develop or implement new innovative technology.
- Most of the administrative staff and decision makers are elderly people, and non-experts in health information technology.
- Many companies produce hospital information systems offering promises and trade programmes that achieve full integrated system, but in reality, it does not happen.
- Difficulties in process maturation.

These results were consistent with the findings of Chi-Hung's study [3] which suggested that the five factors, environmental pressure, system integrity, top management attitudes towards HL7, staff's technological capability, and hospital scale, were identified to influence a hospital's HL7 adoption decision. Abdullah & Thomas [7] found that there was a lack of national action regarding the adoption of health data standards. Kimber and Evanisko (1981) argued that organizations tended to adopt a new technology when they faced competition from other businesses.

### 6.2 Analysis of [Case 2]

Some hospitals have no intention to adopt EHR system because of many reasons. For the environmental dimension; unavailability of financing and lack of competition toward EHR use get the same highest rates of agreement between the study sample with ratio (100%) followed by ratio (61.5%) to lack of a national strategy concerned with using of EHR. For the managerial dimension the highest rate of agreement between the study sample was (63.5%) to lack of strategic plan to use EHR. For the technological dimension lack of specialists in information technology to meet the needs of the hospital get the highest rate of agreement between the study sample with a ratio (36.5%).

Respondents allude reasons to: the plan to adopt EHR system even not included in the work schedule and lack of awareness of EHR or its importance. These results agree with Tanko [24] who has identified that some of the challenges of EHR implementation are the initial huge start-up costs, and the study of Ahmed Sharaf Eldin et al. [9] who emphasized that high cost was responsible for poor adoption of EHR.

The second group of hospitals has already employed EHR system in all hospital systems or a part of them observed in private and charitable hospitals, but the following were observed:

- The physicians rarely work directly with EHR systems.
- Each hospital has its EHR system with different structure.
- They store patient demographics data, financial reports, pharmacy data as a database (tables, attributes, etc).
- Laboratory Information Systems (LIS) and Radiology Information Systems (RIS) give digital data but without connecting it with patient document.
- Physician examinations: Paper based only.
- There is no system for Electronic Nursing Documentation.

### 6.3 Analysis of [Case 3]: Success Factors For HL7 Adoption

Most hospitals (77.8%) adopting HL7 implemented it from 2005 to pre-2010 without external financing, but (55.6%) of them have support of external institutions as (Cerner Corporation, DMS company, Health Insight organization). Not all hospitals (100%) adopting HL7 have exchanged health data with other hospitals in the country using HL7 standards except individual cases. For example, "57357" hospital have a new branch in Tanta governorate which will be fully integrated with Cairo branch.

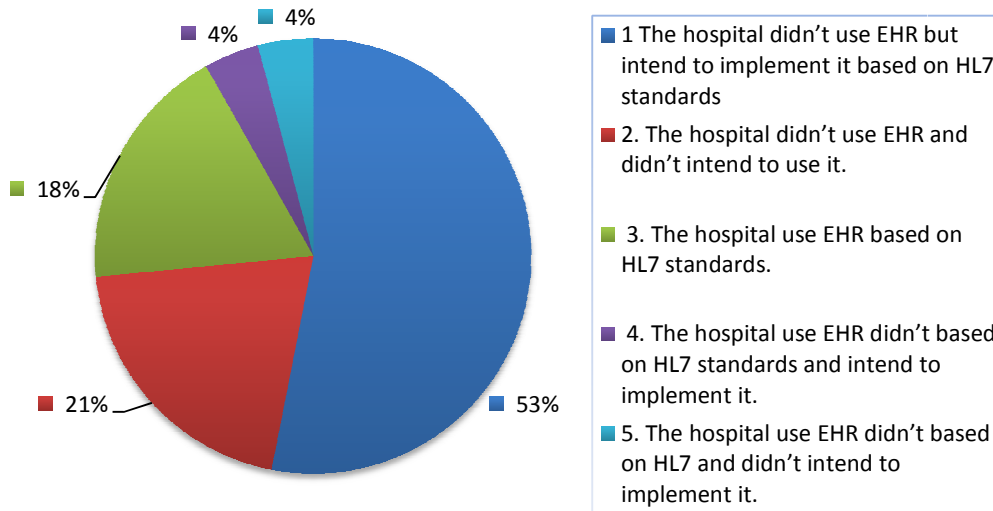


Fig. 1. Hospital adoption for EHR and HL7 standards status

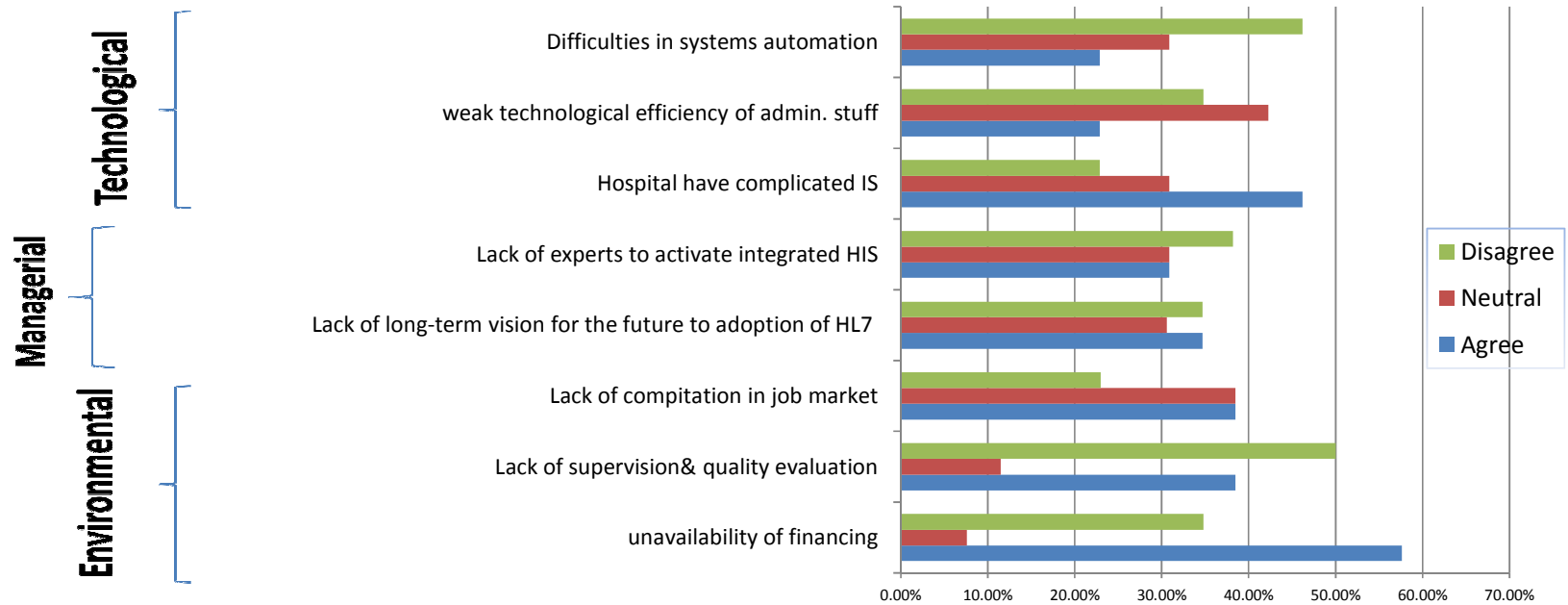


Fig. 2. Frequencies and Percentages of Obstacles to Implement an HL7-Based EHR Programme

With regard to the benefits of HL7 implementation, the highest rates of agreement between the study sample were in the items that raised the quality of medical services and improve and accelerate health care delivery with same ratio (77.8%), while enhancing knowledge transfer among all healthcare providers got (22.2%) which confirms rarity of health data exchange between hospitals.

Many (environmental- managerial- technological) success factors help hospitals to implement HL7 standards and achieve interoperability between their systems. The study sample agrees on the approach of hospital management toward development of a new innovation technology, hospital's long experience in the implementation of HIS and EHR, and highly secured hospital information system, are the more efficient factor that got the highest rates of agreement with a ratio (100%) of the study sample. But the presence of a national strategy for integration in the health field and government facilitates or rewards any adoption of a new innovation technology get the lowest rates of agreement between the study sample with ratio (22%). Most of HL7 adopted hospitals (77.78%) see that there was no clear vision for Egypt to establish an affiliate international HL7 organization. Most obstacles encountered during implementation process include:

- Resistance to change.
- Devices do not support HL7 protocol.
- Vendors develop software which does not support HL7.
- Medical team Adoption.

#### **6.4 Analysis of [Case 4]**

Case of hospitals that use EHR and intend to implement HL7 standards, they expect to achieve this plans within 2 years and supposed the reasons. Lack of additional cost to update the technological infrastructure with ratio (100%), then lack of modifying software interfaces cost and lack of HL7 experts in the hospitals with ratio (66.67%).

#### **6.5 Analysis of [Case 5]**

Case of hospitals use EHR and do not need to implement HL7 standards for several reasons. Lack of competition or absence of a national project for health data exchange, and deficiency in financing factors was rated highest rate of

agreement between study samples with ratio (100%). follow them lack of a future vision for HL7 adoption and lack of HL7 experts in the hospitals.

This case of hospitals was chosen to develop another solution for their information integration needs as: [web services, database synchronization], because they have not the opportunity to use HL7 standards, and in some cases they did not discover their benefits.

## **7. DISCUSSION**

The purpose of Health Level Seven standards is to reduce the complexity of interface design and to facilitate information exchange among various health information systems. In spite of the importance of HL7 standards, there is still a long way to go before the regular adoption in developing countries. The main reason is due to no national strategy or plan to achieve the integration in health sector. The empirical study in Egypt showed that there are 5 different cases for hospitals in adopting Electronic Health Records (EHR) and Health Level Seven (HL7) standards. After analyzing the factors it was clear what the dependant variables that HL7 implementation depends on are, unavailability of financing, lack of competition toward health data exchange, low awareness of HL7 and its importance, management attitude toward HL7 adoption, availability of secured and compatible information systems, long experience of the hospital specialists in implementation of HIS and EHR.

The analysis clarifies that HL7 adopted hospitals are charity and private hospitals. This means that there is lack of government support to adopt new innovative technology such as HL7 in the healthcare sector. After analyzing these factors the researcher found that there was a relationship between HL7 implementation factors with hospital size and hospital category. There is a statistically significant difference in chi-square tests with p-value < 0.05 between hospital category and some of barriers toward HL7 implementation. This means that this hypothesis is partially accepted. There is no statistically significant difference between hospital category and the success factors toward HL7 implementation. This means that this hypothesis is rejected. There is a statistically significant difference between hospital capacity and nearly all barriers toward HL7 implementation. This means that this hypothesis is accepted. There is a statistically significant difference between hospital capacity and some of



success factors toward HL7 implementation. This means that this hypothesis is partially accepted.

## 8. CONCLUSION

Egypt is a country with high population density with a strong need for quality health services. Despite of the importance of HL7 standards as a new technology in healthcare sector, there is absence of national strategy regarding the adoption of HL7 standards. Few hospitals implements HL7 standards individually to have internal integrity between different heterogeneous systems. Unfortunately, Egypt still has a long way to go to have even Electronic Health Records system adopted in all hospitals, still lacks significant evidence of application and use of HL7 standards. This requires from academics and practitioners a number of studies and research in addition to governmental support and strategic plans. Also, this study will guide health authorities with a comprehensive overview about the benefits and roles of HL7, barriers and success factors affecting its implementation. It is hoped that this will help to reform Egyptian health care services.

According to the research study, the researcher presents some recommendations for the experts in the area of eHealth and those responsible for the allocation of informational health system in Egypt. For example; Considering the development of eHealth interoperability as one of strategic objectives of the Egyptian healthcare sector. Allocation of financial and human resources required to provide the use of EHR and HL7 standards. The government should enforce laws to organize the different aspects related with the use of Electronic Health records. Providing computers to all departments that are deficient of these devices in good numbers and specifications is a necessity. Getting rid of paperwork health file and gradually start implementing EHR system to cancel the duplication of data entry is very important. Promotional programmes with support from ministry of health to motivate stakeholders to adopt EHR& HL7 standards. Implementation of awareness campaigns aimed at workers in the areas of eHealth about the importance of HL7. The government should enforce laws to organize the different aspects related with the use of eHealth record.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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