Proceedings of the 2013 Industrial and Systems Engineering Research Conference
A. Krishnamurthy and W.K.V. Chan, eds.

The Role of IS Infrastructure and Organizational Context on Implementation of Electronic Health Records Systems

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Abstract

This research explores the role that Information System (IS) infrastructure and organizational context play on the implementation of Electronic Health Records (EHR) Systems. A number of indicators can be used as a proxy for IS infrastructure such as: Information System (IS) Department Budget allocation, percentage of full time IS staff and the number of technical trainings provided by the IS department to the clinical staff. Data was obtained from the Healthcare Information and Management Systems Society (HIMSS) database, a non-for profit organization that evaluates the use of information technology in the health care industry. This paper reports on the development of a model describing the relationship between factors of IS infrastructure, organizational context and implementation of EHR systems. A regression equation was formulated to evaluate the predictive ability of the variables. The results of this regression analysis were used to explain the relationship between the factors related to the investment in IS infrastructure and implementation of EHR systems.

Keywords

Electronic Health Records Systems, Health Care Management, Information Systems Implementation, Training, Technology Change.

1. Introduction

The application of Information and Communication Technology (ICT) in the healthcare sector has been growing rapidly over the past few years. The reason behind its rapid growth is considered to be its ability to improve effectiveness and efficiency in the clinical output [1]. In general, one can say that ICT has changed the way in which clinical staff conducts their business. In particular, Electronic Health Records (EHR) systems are acknowledged as having the potential to significantly enhance the clinical processes and to improve efficiency.

EHR is a generic term used for all electronic patient care systems that coordinate the storage and retrieval of individual medical records with the aid of computers via a secured network to authorized health personnel. According to Quakk et al. [2], the purpose of an EHR system is to facilitate clinical and administrative processes to reduce medical errors and cut healthcare costs. It is used to gather clinical information and is designed to process notes or data and to support other clinical functions such as computerized provider order entry (CPOE) and clinical decision support systems (CDSS). Some of the basic features of this system are tools like billing and scheduling which are used in administrative processes. While these are the basic features of this system, the most important features are its data storage capacity and data security as well as a centralized database system. Such features facilitate clinical staff access to medical history or other patient information electronically, which may help reduce errors that occur when such data are processed manually. It also stores information on treatment procedure; hence similar cases in the future can be easily solved by following the same procedure, thereby reducing the total treatment

time. As a result, EHR systems promise to facilitate clinical decision-making and minimize the potential mistakes due to the inaccuracy and incompleteness of paper records.

An EHR system is built up of several sub units. For example the unit "Physician Clinical Procedure" has Physician Order Entry, Results Review and Patient Location/Patient List fields. It maintains a list of patients a physician is tending to. Similarly, "Clinical Decision Support" has Decision Support, Report Writer, PDA Support, Data Warehouse, and Outcome Measurement/Cooperative Data Unit. All of these units are typically connected via central database of the individual health care providers, as well as to the EHR units of other healthcare providers. Clinical staff involved in a clinical procedure has access to information about similar clinical procedures. In general, this allows the clinical staff to gather information about the medical procedure and access information regarding a medical case. Similarly, a patient can also view information regarding clinical procedures, and have a general idea about the type, general cost and length of total procedure.

Studies conducted so far indicate that EHR system helps support clinical practice [1]. From the view point of both the clinical staff and patient, it can facilitate clinical processes. For clinical staff, the help comes in form of less paperwork, better record management system, and easy retrieval of past records aimed at enhancing medical procedures. For patients, the help comes in form of less time spent on clinical procedure, which will save them money and get them efficient healthcare. Hence, it seems that healthcare providers and patients can really benefit from implementing this system.

Most existing research supports that EHR system implementation is the way forward for the health care industry. However, many healthcare service providers have only accomplished partial EHR system implementation. There are many barriers preventing a full EHR system implementation. The objective of this research is to identify key factors related to information systems infrastructure and management support that play a role in the implementation of EHR system.

2. Information Systems infrastructure and Management Support

A comprehensive electronic record system touches every level of the organization, and IS trainings to the non-IS staff plays an important role in the successful implementation of the EHR system. Generally, non-IS staff have less expertise in handling IS system. The success of EHR system depends on the use of this system by non-IS staff like nurses, doctors and other non-technical and non-medical staff working in the healthcare sector. Hence, it is very important that staff members are comfortable using the system. Providing quality trainings and information sessions is very important for the successful implementation of the EHR system. Many institutions set up optimization teams composed of technical support, process improvement, and dedicated support for physicians while implementing EHR [3].

Health System executives and board of directors sometimes overlook the fact that implementation is an organizational competency, and a competitive advantage. Even though EHR implementation was initially expected to be a relatively easy transition, a recent study reported that only 10 percent of hospitals in the US had fully implemented EHR throughout their facilities [4]. Some of the reported barriers to EHR implementation have been fear of the unknown and lack of technical skills which can effectively be overcome with training, coaching, appropriate knowledge transfer, and strong leadership management. Information technology promotes the practice of evidence based management practices [5]. An IT system can minimize uncertainty, and help in clinical decision making when there is no evidence-based protocol for the management of a patient. Communication across care providers renders the case management more of a system approach, than one where an individual doctor deals with the uncertainties.

One of the essential components of health information technology implementation is a well-trained and competent workforce. A recent study using data from the HIMSS Analytics™ Database shows that there are approximately 108,390 IT professionals in health care in the US [6]. Health care providers need to develop a staff training model that is specific to job roles and responsibilities and provide onsite support before, during, and for a specified period of time after implementation. Most studies done in the United States (US) have focused on one group in the workforce, such as IT or health information management (HIM) professionals. Hersh and Wright [4] assessed IT staff ratios in integrated delivery systems of varying size. Among 85 such organizations studied, there was a consistent finding of about one IT staff per 56 non-IT employees, which was similar to the ratio noted in other

countries such as England. The major roles for IT staff were listed as programmer/analyst (51%), support (28%), telecommunications (16%) [6].

An additional workforce study has focused on a specific HIT application, estimating the workforce necessary to deploy a Nationwide Health Information Network in the US [6]. For a five-year implementation time frame, there would be an estimated need for 7,600 full time employees (FTE) for installation of EHRs for 400,000 practicing physicians who do not currently have them, 28,600 FTE for the 4,000 hospitals that do not have EHRs, and 420 FTE to implement the infrastructure to connect the network [6].

Successful implementation provides the necessary platform to more effectively launch new strategic initiatives, test care concepts, and track results in any setting of care. Management support for information systems infrastructure, implementation, and deployment is expected to not only help HIT leaders implement systems better, but also assist educational programs in determining the best curricula for students training to fill these roles [7]. Better understanding of the HIT workforce will also allow health care leaders to better understand and overcome the barriers to more effective HIT adoption.

3. Methodology

The goal of this study is to identify the role of IS infrastructure and management support on successful implementation of EHR systems.

3.1 Sample

This study used data from the Healthcare Information and Management System Society (HIMSS) Analytics™ database. HIMSS is a US not-for-profit organization dedicated to promoting a better understanding of health care information and management systems. This database contains self-reported data from about 5,000 US hospitals, including data such as number of beds, total staff FTE, total IT FTE (as well as broken down by major IT job categories), EHR applications, and the vendors used for those applications. The HIMSS Analytics Database is the largest and most comprehensive source of data of its kind. Using a deductive method, this research will identify the factors of IS infrastructure and management support that best predict successful implementation of EHR systems. In this case, we will analyze available data from healthcare service providers throughout U.S.A. The dataset includes 1032 healthcare service providers from 49 different states. The unit of analysis will be Integrated Delivery Systems (IDS) and Independent Hospital Systems. That is, health care organizations belonging to a parent holding company will be merged together as one data set since they typically make joint decisions and joint implementation in terms of EHR implementation. Freestanding data centers and Home Care providers were excluded from the analysis

An integrated delivery system (IDS) is a network of health care organizations under a parent holding company. Some IDS have a common insurance component, while others are a network of physicians only, or of physicians and hospitals. Thus, the term is used broadly to define an organization that provides a continuum of health care services [8]. An IDS is an organized, coordinated, and collaborative network that links several healthcare providers to provide a coordinated, vertical continuum of services to a particular patient population or community. It is also accountable, both clinically and financially, for the clinical outcomes and health status of the population or community served, and has systems in place to manage and improve those outcomes [9].

3.2 Variables

We assessed IS infrastructure through three variables: IS department budget, IS staff ratio, Number of training provided to non-IS staff. In order to measure extent of management support we used two proxi variables: development of IS plan and IS steering committee. All the variables will be defined next.

IS department budget is measured as the percentage of the total budget allocated to the Information System department of healthcare service providers. This variables represents the IS department budget as a percentage of the total budget for the hospital system.

IS staff ratio refers to the ratio of full time staff that work under the Information System Department per number of hospital beds. It was measured as a ratio of number of number of IS full time staff per number of patient beds.

Total number of technical trainings. Total number of training units provided over three years related to Information technology provided to nursing home staff per year. In our analysis we consider trainings such as “integration of

new EHR unit", "shifting to paperless environment", "upgrade existing system", "computerized patient record" and "decreasing medical errors". The training variable includes those training sessions conducted prior to attempting EHR implementation.

IS Steering Committee. Dicotomous categorical variable that assesses whether the hospital the system reported having formal IS steering committee. This variable will be used as a proxy of managerial support for the EHR implementation.

IS Plan. Dicotomous categorical variable that assesses whether the hospital system reported having an IS plan in place. This variable will be used as a proxy of managerial support for the EHR implementation.

Number of EHR Units Implemented was the dependent variable. Total Number of EHR units is the total number of clinical units that have already been implemented and are operational. The clinical units include "Physician Portal", "Consumer portal", 'Document management", "Clinical Data Repository", "Electronic Form Management", "Nurse staffing/scheduling" and other such units. We have only included units that are "live and operational" and those units that have "installation in process", "Contracted/Not Yet Installed" and "Not reported" all are coded as non-implemented. Hence, this variable accounts for the total number of fully operating units. Data on Implementation corresponds to units implemented as of the end of 2010.

3.3 Statistical Hypotheses

The proposed statistical hypotheses in alternative form are the following:
H1: There is a positive relationship between ratio of skilled technical staff and numbers of EHR units implemented in the hospital systems.
H2: There is a positive relationship between number of technical trainings provided and numbers of EHR units implemented in the hospital systems.
H3. There is a positive relationship between IS budget and numbers of EHR units implemented in the hospital systems.
H4: Hospital systems with an IS plan will implement a significantly higher average number of EHR units than those without it.
H5: Hospital systems with an IS Steering Committee will implement a significantly higher average number of EHR units than those without it.

3.4 Analysis

Linear regression analysis was used to develop a predictive model of EHR implementation success based on the independent variables previously discussed. We used PASW/SPSS 20 to conduct the regression analysis. The regression assumptions were evaluated and they were reasonably met based on the sample data. Four assumptions were tested:

- Linearity of the relationship between dependent and independent variables This was tested using scatter plot of the observed versus predicted values.
- Independence of the errors was fulfilled.
- Homoscedasticity (constant variance) of the errors. Residual plots of standardized vs. predicted value supported this assumption.
- Normality of the error distribution. The normal probability plot of the residuals suggests that the error distribution is fairly close to normal.

4. Results

The regression model tested with the analysis was:

$$Y = \beta_0 + \beta_1 B + \beta_2 T + \beta_3 I + \beta_4 T * I + \beta_5 P + \beta_6 C + \varepsilon \quad (1)$$

Y = Number of EHR units installed
B = Information System Department Budget per year (in % of overall operating budget)
T = Number of IS training programs offered by the healthcare service providers
I = Ratio of full time IS staff per bed
P = Dicotomous variable indicating whether or not the IDS had a IS plan
C = Dicotomous variable indicating whether or not the IDS had an IS steering committee

The initial regression model including IS budget showed that the variable was not a significant predictor of number of EHR units implemented. IS budget (B) was eliminated from the analysis due the high values of collinearity with Training and IS staff. The R^2 of the revised model was not significantly reduced when this variable was taken out.

The resulting model was statistically significant ($p<0.0001$ $F_{1,1031}=143.72$) with $R^2=0.42$. Table 1 indicated the standardized coefficients and corresponding significance of each of the regression terms.

Table 1. Regression Coefficients

Model	β	T	Sig
(Constant)		22.741	.000
Number_trainings	.259	7.887	.000
Full time IS employee total	.449	11.056	.000
Steering Committee	.234	8.934	.000
IS Plan	.230	9.027	.000

Based on the previous analysis, the data supports all hypotheses except H3. That is, within the factors related to IS infrastructure, it was found that both training and ratio of full time IS personnel significantly contributed to increased levels of success in EHR implementation. Also, IDS networks with a yearly plan for IS and an IS steering committee were able to implement larger number of units than those without. Interestingly, IS budget did not show a significant impact on number of units implemented, suggesting that is not the extent of the IS investment that influences success but the strategic approach to using the IS budget. In particular, additional investments in full time IT personnel and training seem to pay off in terms of EHR implementation success.

5. Conclusions and Limitations

Despite calls for wider use of health information technology (HIT) to improve health, health care, public health, and biomedical research, there are still barriers to its adoption. Due to EHRs' complexity, the usability of these systems is crucial to ensure safety and to enable clinicians (users) to focus on their patients rather than the technology [10]. Our results provide a comprehensive picture of the impact of management support and IS infrastructure on successful EHR system implementation.

We found evidence that both training and ratio of full time IS personnel significantly contributed to increased levels of success in EHR implementation (See Table 1). This will not only help HIT leaders implement systems better, but also assist educational programs in determining the best curricula for students training to fill these roles. Better understanding of the HIT workforce will also allow health care leaders to better understand and overcome the barriers to more effective HIT adoption. EHR implementation may increase the demand for higher-skilled clinicians making the schools aware of curriculum changes [11].

The analysis suggests that IS budget did not show a significant impact on number of units implemented (See Table 1), suggesting that it is not the extent of the IS investment that influences successful implementation but the strategic approach to using the IS budget. With greater EHR sophistication, system cost raises, and IS budget is bound to increase. Additional investments in full time IT personnel and training seem to pay off in terms of EHR implementation success. Lack of training and poor coordination even with the most expensive and sophisticated EHR system may lead to inefficiencies and increased risk for adverse patient outcomes [12]. An intriguing implication of these results is that increasing EHR sophistication in the long run with increased costs must be taken highly in consideration when allocating financial resources.

Our results also suggest that hospital systems with an IS plan were able to implement a significantly higher average number of EHR units than those without it. Hospital systems with an IS Steering Committee will implement a significantly higher average number of EHR units than those without it. Comprehensive EHR implementation is only possible through strong, clear leadership. An organization should use the same clinical experts who helped to design and test the EHR system as trainers. Ultimately, these employees are the best leaders for physicians and staff through the transition. It is far better to take the time necessary to educate and train clinicians on how to effectively use EHR, than to rush the process and potentially create conflict with clinicians [13].

There are limitations to the data and our analysis. The HIMSS Analytics Database is self-reported and incomplete. Also, our examination of some of the variables, such as training, takes a one-dimensional approach by looking at extent of training without evaluating the effectiveness of the training initiatives. Further research is essential to better characterize all types of skills and training needed for successful adoption of health information technology, including role requirements, competencies, and optimal education.

Acknowledgements

We gratefully acknowledge HIMSS Analytics for use of the HIMSS Analytics Database.

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