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# **Clinician Satisfaction with In-house and Cloud-based EHR Vendors**

*Completed Research*

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## **Abstract**

This paper examines the factors that affect clinician satisfaction with electronic health records (EHR) vendors that provide in-house and cloud-based solutions. The study is concerned with the organizational level of different healthcare organizations. The model combines the IS Success model and the Task Technology Fit model, to best fit the health information systems. Five research hypotheses derived from the model and are going to be empirically tested using a field survey of EHR systems characteristics and its influence on the organization's tasks achievement and mission alignment.

## **Keywords**

Electronic Health Records, Cloud Computing, Task Technology Fit Model, IS Success Model, Task Facilitation, and Mission Alignment.

## **Introduction**

Healthcare systems have been evolving and adopting the use of information systems significantly. As well as, Electronic Health Records (EHR) are becoming dominant in most health institutes, due to their perceived advantages and improving care quality. EHR systems have been establishing a foundation for a safer and more productive healthcare systems (Gan and Cao 2014). However, in some health institutes there could be millions if not billions of electronic health records that need to be accessed, managed, updated, shared, and secured. As a result, healthcare institutes have additional responsibilities concerning the management of EHR. An increasing number of users are moving their data from the local to the cloud. With the help of cloud computing, EHR systems integration and sharing and exchange of electronic medical records between various healthcare providers could be easier especially for hospitals and clinics with fewer resources (Li et al. 2011).

Cloud computing is defined as the delivery of computing services such as databases, software, networking, and analytics in addition to storage by a remote service provider over the internet (the cloud) (Mell and Grance 2011). For healthcare institutes, opportunities for better data processing and sharing among patients and healthcare personnel arise. In addition, the cloud services keep the focus of the health institute on its core business, and reduces EHR physical storage space (Casola et al. 2016). As well as, it leads to a better, easier, and faster integration of medical data between the cooperative health institutes, which itself has advantageous values. These advantages include reduced errors, better understanding of the patient's medical case, reduced redundancy of treatments, and faster response in case of emergency. While cloud services expands, some challenges cannot be ignored. Privacy of crucial data, costs of cloud services, compatibility with the existing IT infrastructure, knowledge and experience of users, should all be considered when health institutes use the cloud for EHR systems.

This study focuses on the factors that affect health organization's satisfaction with the cloud services vendor. After delving deep in the literature and the theories such as IS Success Model I and II, we propose some major factors that affect organization's satisfaction. In sum, this paper has the following objectives: (A) to develop an organizational level model to explain the factors that affect EHR system's vendor' satisfaction in health institutes that adopted cloud EHR and for health institutes that is looking forward moving to the cloud and choosing from the different cloud services vendors and options. (B) Empirically test and validate the proposed model.

This study is expected to make several contributions to research and practice. It is concentrating on health care institutes' electronic health systems that are either in-house or outsourced to be managed on the cloud by an external service provider. The research questions that this paper is trying to answer are: What are the main factors that affect the healthcare organization's satisfaction with the vendor of EHR systems? Are these factors different for the in-house and the cloud-based EHR systems?

## **Research Background**

There are some studies that focused on the electronic health records systems and the factors that affect their efficiency. For example, Kazley and Ozcan (2007) suggested that organizational and environmental factors will have an effect on EMR adoption. Another study by HsiaoYi, LiEmail, ChenHsi and Ko (2009) suggested that organizational, environmental and technological factors affect the decision to adopt mobile nursing information systems. Moreover, Kuo (2011) suggested that hospitals should be evaluated comprehensively before adopting cloud technologies. He proposed that this evaluation should cover the following aspects: technology, security, management, in addition to the legal issues. Moreover, a study by Mu-Hsing (2012) suggests a strategic planning model for health organizations to move traditional IT Infrastructure towards the cloud. The model suggested 4 iterative stages that are: Identification, Evaluation, Action, and Follow-up. This model helps the Healthcare organization to examine environmental factors that may affect it, assess its capabilities and identify the strategies for moving to the cloud. Another study suggested a theoretical model for clinical information systems success from the nurse perspective, and it found that information quality, system performance and facilitating conditions explained 70% of Nurse Satisfaction with the clinical information system (Garcia-Smith and Effken 2013). Also, another study investigated the factors that affect the fit between nursing tasks and mobile nursing information systems in addition to the relationships between the task-technology fit of mobile nursing information systems and nurse performance depending on the task-technology fit model (Hsiao and Chen, 2012). According to a study by Lian, Yen, and Wang, There are five critical factors that affect decision to adopt cloud computing technologies in hospitals that are data security, perceived technical competence, cost, top manager support, and complexity (Lian et al. 2013).

Following the advice of many scientific research reviewers of building cumulative research studies based on previous work and studies, two major theories in the literature provide the theoretical foundations for this study. IS Success Model I and II and Task Technology Fit Model. They offer a conceptual lens for investigating the variables that affect vendor satisfaction. However, these models are generalized for different systems, and as a result they could have some aspects and measures that do not apply for the Health Information Systems HIT systems. Our proposed model attempts to focus on the characteristics and specifications that are compatible with healthcare organizations.

Task Technology Fit has been examined and extended by many studies to measure net benefit of electronic health records and user performance including Willis et al. 2009, Garcia-Smith and Effken 2013, Ancker et al. 2011, and many others. Similarly, the IS success model has been adapted in some studies to test the effectiveness of EMR systems for hospitals including a study by Otieno et al. (2008).

Information Systems Success Model was found by McLean and Delone in 1992. It seeks to provide IS success model (process causal model) that explains the relationships between six major determinants of IS Success that are system quality, information quality, use, user satisfaction, individual impact and organizational impact. It was first established by the two authors. Ten years later they had refined it in accordance with the development and complex reality of information technology systems and the emergence of end-user computing and IS services (Delone and McLean, 2003). The D&M updated IS success model has 3 independent and interdependent variables: system quality, Information quality, and service quality. These variables affect user satisfaction and intention to use/use. Finally, these two

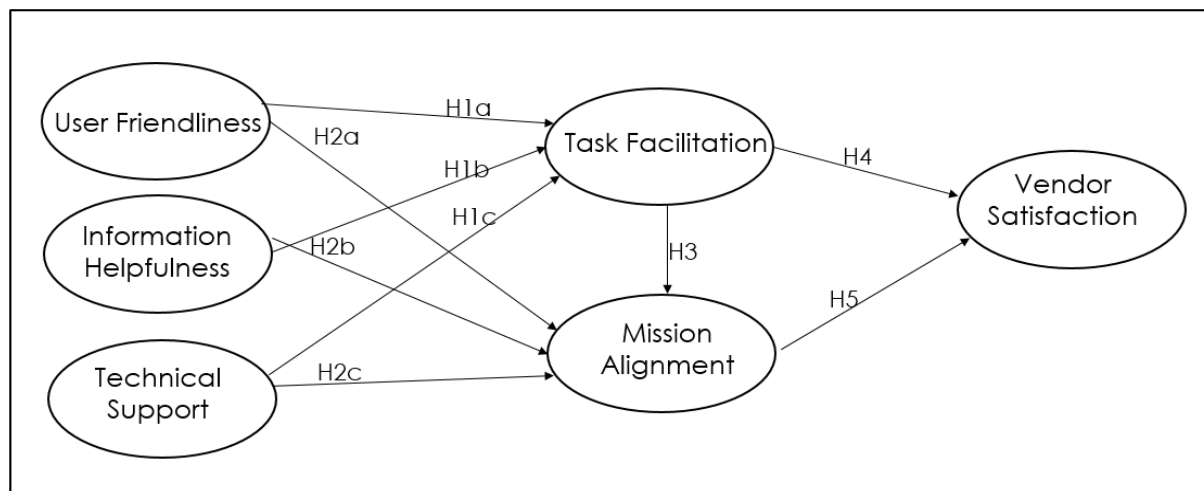
mediators affect the dependent variable the net benefits (substituted for the individual and organizational impact in the previous model), which also affect the intention to use and the satisfaction of the technology. This temporal and causal model measures the complex dependent variable in IS research (Delone and McLean 2003). It helps researchers to understand and measure the dimensions of information systems and technologies success. Furthermore, the appropriate specification and application of the IS Success Model should be dictated according to the context (Delone and McLean, 2003). And in this paper, the model and its related constructs are specified according to the healthcare systems context, since the IS Success Model is a general framework that could be used to many different systems and we want to specialize it to best fit to the EHR system.

The Task Technology Fit Model (TTFM) posits a relationship between information technology and individual performance, in which the technology must be utilized as well as it must fit well to the task it supports (Goodhue and Thompson 1995). The task technology fit model is considered one of the significant determinants of whether the system is believed to have relative advantage. The model defines the task technology fit as “the degree to which a technology assists an individual in performing his or her portfolio of tasks” (Goodhue and Thompson 1995). Although the TTF focuses on performance impacts at the individual level, this individual performance impact affects the organization’s whole performance according to the IS Success model one, in which individual impact is a direct predictor of organizational impact. Additionally, the TTF happens at two levels one is the strategic business level and the other is the functional level, according to the Strategic Alignment Model (Henderson and Venkatraman 1993).

While these previous models and theories are of the most powerful and effective in the IS, a model that integrates constructs from both of them to suit with health care organizations may offer improvement over these models separately. Using an integrated and adjusted model should lead to better understanding of HIT and its related technologies and tasks.

## Research Model

Drawing on the literature reviewed, the research model for this study, adapt the IS success model and the task technology fit model to be customized for the EHR systems (in-house and cloud based). The model shows that EHR system’s characteristic influence task facilitation and mission alignment of the healthcare organization that can have a direct effect on satisfaction with the vendor of the EHR system. The independent variables in this model are user friendliness, information helpfulness, and technical support. The suggested model is shown in figure 1 and the constructs are defined in Table 1.



**Figure 1. The Proposed Model.**

User Friendliness is defined as the extent to which using the EHR system is intuitive to users (e.g. navigation, data entry, output generation) and does not demand too much effort during the process. “The choice of the success variable is often a function of the objective of the study, the organizational context, the aspect of the information system which is addressed by the study, and the independent variables under investigation” (Delone & McLean 1993). In order to apply IS success model, some of the measures from the

model's categories, which best suit for the studies context, should be combined produce a comprehensive measurement. According to that, user friendliness is a measure of system quality in terms of usability. It measures the complexity of the EHR system's interfaces, and how they are easy to use and interact with. This feature is of an important value for the health care institute, because different users with different IT skills and experiences exist. Users (e.g. physicians, clinicians, patients, administrators) prefer to use simple applications. The interfaces should be simple and elegant (Gan & Cao 2014). Moreover, the emergence of various electronic devices that are used in a daily bases for work and communication, makes simple and compatible EHR application that are available for the different devices necessary (Li et al. 2011). Simplicity could have an effect on medical diagnostic and treatment improvement, through the easy retrieval of medical history and the unified medical data.

For instance, the in-house EHR systems interfaces usually lack standardization, and thus data exchange and sharing between different institutes is more challenging. Also, servers and hardware infrastructure are located in the healthcare organization itself. As a result, it bears the burden to purchase, secure, and maintain them. In addition, in the in-house EHR systems, the organization needs to have sufficient and well-experienced IT staff who is responsible for managing, maintaining, and fixing the problems with the EHR system. On the other hand, the cloud EHR system will have a standardized system, and will be responsible for the hardware infrastructure. However, when moving to the cloud, it is important to consider if the adapted cloud technologies and applications operate compatibly with the organization's existing IT infrastructure and software. Standardized cloud-based applications that can be used by many health providers, government agencies, and insurance institutions, are beneficial for easy quick sharing and exchanging of data. These data include medical history, lab results, X-ray images, and many others, especially in case of emergency (Ahuja et al. 2012). However, in the in-house HIT, the health data are disperse. Health data are located in different separate health institutes, or department, which makes data integration difficult (AbuKhousa & Al-Jaroodi 2012).

If the EHR system has the personalized features for different users, this will allow the users to interact more effectively with the system and obtain the required information easily. Also through integrated appointment system that can link doctors and patients together, automated coding, automatic delivery of information to and from laboratories, and integrated patient information, the organization can run more efficiently, save time spent on doing secondary tasks, and medical practice management can be improved. All of that will be reflected on the medical organization's tasks and functions.

In health care organizations, mostly the employees are from the medical field with health related jobs and experience. As a result, they would not be with brilliant experience with the IS technologies and applications. Due to that, when the interface of the cloud system is easy to use, and functions could be logically done without the need to spend additional time to learn sophisticated procedures in order to get the information they want, this will increase their use of the EHR system. Then they will have easy and quick access to patients' records, and time will be reduced for retrieving the required information, which will be reflected on performing the tasks more smoothly. "Prior research has shown that system interfaces affect perceived ease of use EOU or related concepts, such as user interface satisfaction" (Mathieson & Keil 1998). According to that hypothesis 1 is proposed:

H1a: User friendliness of the EHR system has a positive effect on task facilitation of the health organization.

Construct	Definition	Related construct from literature	Definition
User Friendliness	The extent to which using the EHR system is intuitive to users (e.g. navigation, data entry, output generation) and does not demand too much effort during the process.	System Quality (From IS Success Model)	Measurement of the information processing system itself that reflects the engineering-oriented performance characteristics of the tested system, such as, ease of use and system flexibility.

Information Helpfulness	How the EHR system facilitates the capturing, processing and utilization of healthcare information.	Information Quality (From IS Success Model)	Measurement quality of the information that the system produces, such as the form of reports and the formatting and accuracy.
Technical Support	The extent to which the EHR system helps the healthcare organization achieve tasks in a more efficient and effective way (e.g. shorter response time, better productivity, cost reduction, and better decision-making).	Service Quality (From Updated IS Success Model)	The measurement of tangibles, reliability, responsiveness, assurance and empathy dimensions.
Mission Alignment	How the implementation of the EHR system is consistent with the organization's strategy to fulfill its healthcare mission.	Strategic Alignment	"The link between the business strategy and the IT strategy" (Henderson and Venkatraman 1993).
Task Facilitation	The extent to which the EHR system helps the healthcare organization achieve tasks in a more efficient and effective way (e.g. shorter response time, better productivity, cost reduction, and better decision-making).	Task Technology fit at the functional level	"The link between organizational infrastructure and processes and IS infrastructure and processes" (Henderson and Venkatraman 1993).

**Table 1. Proposed Constructs and the Related Constructs from Literature**

Having a user friendly EHR system is the key for using it happily by physicians, managers, and others. Clear procedures and easy processes of the system help users (e.g. physicians) do their job faster and not wasting time in figuring out how to do some procedures and functions in the system. This will be reflected on reducing patients waiting time and patients overall visit time, fast and secure connection between different sub-systems, such as lab sub-system and clinic sub-system, and easier integration of patient's information. All of that will help with better medical decisions, faster response and service to patients, and thus brings better and higher quality healthcare and patient satisfaction and care. So the EHR system support the objectives and strategies of the organization (Bush and Palmisano 2009). And thus we hypothesize:

H2a: User friendliness of the EHR system has positive effect on the mission alignment of the healthcare organization.

Information Helpfulness refers to how the EHR system facilitates the capturing, processing and utilization of healthcare information. It is a measure of IS information quality in terms of how meaningful, accurate and timeliness the information product is to users (Delone & McLean 1992). Healthcare information is of high importance. With effective EHR systems such information can be produced in a better format and quality. For instance, lab results will have less errors when integrated by the EHR system, because of automation of some processes. Also, data retrieval will be faster and easier, which results in faster responses and better diagnostics for patients' medical cases. Because cloud EHR systems are standardized and the information obtained from them is available for many health organizations with privilege, this allows for data integration and comprehensive EHR for patients. According to a study by Botsis et al. (2010), only 1589 of 3068 patients who had ICD-9-CM diagnoses for pancreatic cancer had corresponding disease documentation in pathology reports. Incompleteness of data was the leading data quality issue. Inaccuracy and inconsistency were found to be the next problems. Effective EHR systems would not have the previous problem. Cloud-based systems are updated more frequently than in-house systems with the latest IDC

codes, so the information collected are more standardized and accurate. Information helpfulness of the EHR system help users to do their job better and help the organization to achieve its tasks more effectively, because it provides more reliable and understandable information, and thus help users to better understand and utilize them to complete the organizations tasks and functions. As well as, it helps the organization to offer a better healthcare service and serve more patients. Thus, H1b and H2b are proposed.

H1b: Information helpfulness of the EHR system has positive effect on task facilitation of the health organization.

H2b: Information helpfulness of the EHR system has positive effect on the mission alignment of the healthcare organization.

Technical support refers to the services provided by technicians with readily available help and guidance to EHR users. It is closely related to service quality in terms of responsiveness and assurance pertaining to IS employees' support (Delone & McLean, 2003). In the cloud-based EHR systems, the service provider is responsible for providing customers with training to use the new system, and update, back-up, and maintain the system. In addition to being responsible for the security of the EHR system information. Communication between cloud support system technicians and customers could be formed using online chat to allow for instant flexible communication with the user or through email communication and many others. Technical support from the e-health cloud is of high importance for the health organization, due to the importance of fast responses and the 24-hour availability of the technical support for the health organization, which services cannot be postponed or delayed, since it deals with critical human health. Additionally, the technical support agent needs to use clear and understandable concepts for the customers when they communicate, to help the customer understand the system better or fix the problem efficiently.

The cloud EHR system technical staff is usually well experienced, because they have better understanding of the system, and they deal with more than one organization so they are used to many problems that occur with the system and can fix them faster and more efficient than the in-house EHR system technical staff. Moreover, the cloud service provider technical staff is expected to have a larger number of employees than the in-house system, so that they can cooperate and integrate their different skills and experience to better serve the customer and meet their needs. So that problems with the system could be fixed better and as a result the tasks of the organization will be facilitated. From there Hypothesis H1c and H2c are proposed:

H1c: Technical support of the EHR system will affect the task facilitation of the health organization.

H2c: Technical support of the EHR system has positive effect on the mission alignment of the healthcare organization.

Task facilitation refers to the extent to which the EHR system helps the healthcare organization achieve tasks in a more efficient and effective way (e.g. shorter response time, better productivity, cost reduction, and better decision-making). It pertains to the functional level of task-technology fit (Goodhue and Thompson 1995), (Henderson and Venkatraman 1993). This level deals with "the link between organizational infrastructure and processes and IS infrastructure and processes" (Henderson and Venkatraman 1993). In other words, it implies how the decisions of the IT department improve the choices made in the business domain (Henderson and Venkatraman 1993). The EHR systems plays a facilitating role to enhance the functional integration of the IT of the healthcare organization and the business strategy. The Office of the National Coordinator for Health Information Technology in the US indicated that EHR systems reduce transcription costs, save time using centralized chart management and electronic lab results, and enhance medical practices by automating code procedures and managing claims. All of that will be reflected on diagnosing more patients and gaining more revenues. The cloud based EHR systems could supply what the in-house based systems lack and thus add value to the organization and bring investment revenues (French Joel 2015).

Using the cloud EHR system, Physicians could interact with others easier than in-house health Information Systems, and have a second opinion from other specialized doctors to better diagnose the confusing cases, due to the integrated system and its standardized templates and applications and the easier connectivity. Also, cloud based EHR allow for remote monitoring for patients using real-time control of medical devices that are connected to the cloud system (Moustafa et al. 2016). Relating to the task technology fit theory, in which task characteristic and technology characteristics affect task technology fit, task facilitation will affect

mission alignment, and user friendliness, information helpfulness, and technical support will also affect mission alignment. Accordingly H3 is proposed.

Health IS alignment with strategy has been considered to be an important factor to realize the expected outcomes of information systems in healthcare (Bush and Palmisano 2009).

H3: Task facilitation has a positive effect of the mission alignment of the healthcare organization.

Mission alignment refers to how the implementation of the EHR system is consistent with the organization's strategy to fulfill its healthcare mission. It is closely related to extended notation of task-technology fit at the organizational level (Strong & Volkoff, 2010). "It deals with the capability of the IT functionality to both shape and support business strategy" (Henderson and Venkatraman 1993). Mission alignment is a measure of the EHR system's ability to help the organization deliver a high quality service, improve healthcare, and/or gain patient's satisfaction.

In-house and cloud-based EHR systems may vary to some extent on how they are aligned with organizational mission. In particular, the cloud-based solution allows organizations to focus more on core functions rather than being distracted by technological issues like maintenance, training and security. For instance, researchers found that decision support systems based on EHR data is mission-critical for health organizations (George, Kumar, & Kumar, 2015).

In contrast to the in-house system, in the cloud based EHR, the healthcare organization could focus better on its primary responsibilities and services. Because storing and managing the health information is moved to the cloud provider, the IT responsibilities for the organization are no longer a burden that would prevent the organization from performing its job efficiently. Mission alignment result in the relief of technical expertise and security/privacy responsibility to focus on healthcare service. As a result it will be satisfied with the vendor services and products.

Vendor satisfaction is defined as the extent to which a healthcare organization is satisfied with the EHR vendor (cloud-based or in-house). This is the dependent variable in this study, which measures if EHR system service provider satisfies and meets the health organization's needs and requirements. This measure of high importance, and according to Delone and Mclean, information satisfaction is considered the most used single measure of Information System's success. They justified their assumption with three reasons: (1) Satisfaction has high validity. (2) The availability of reliable tools to measure satisfaction such as the Bailey and Pearson instrument. (3) Most of the other measures "are either conceptually weak or empirically difficult to obtain" (DeLone & McLean 1992).

As more and more applications and services are migrated to the cloud, there are increasing number of cloud service providers, and as a result there is a high competition between cloud providers to attract more customers and sustain existing customers. Customer satisfaction includes satisfaction of service, costs, and cloud EHR functionality. When the EHR system help the healthcare organization to achieve tasks efficiently and help it to be mission critical, this will result in satisfaction with the EHR vendor. As a result H4 and H5 are proposed.

H4: Task facilitation has positive effect on vendor satisfaction.

H5: Mission alignment has positive effect on vendor satisfaction.

The type of the EHR system moderate the relationships in the proposed hypotheses, where the cloud based system relationships has different strength compared to in-house based system.

## **Methodology**

In order to test the hypothesized relationships, a survey questionnaire was distributed to a variety of health organizations (hospitals, health clinics, and therapy centers). At this stages, 60 observations were collected from clinicians. The proposed model is tested using partial least square (PLS) with Smart PLS 3.0. All indicators are modeled as being reflective of their constructs. Item reliability, construct validity, and discriminant validity were assessed. In addition, a multi-group analysis was conducted to compare the results across cloud-based and in-house EHR solutions.

## **Results**

Based on the responses, this study validated the measurement. Among the six constructs, the values of Cronbach Alpha range between 0.802 and 0.933. As they were all above 0.7, the responses exhibit acceptable internal consistency. For each construct, individual item loadings were above 0.70, and average variance extracted (AVE) is well above 0.5 (smallest value: 0.721), supporting convergent validity. The square root of AVE was greater than the correlation between this particular construct and the other constructs, supporting discriminant validity. To test for collinearity among explanatory variables, VIF test was conducted. No VIF values were above 8 (most were below 5), and that indicated no strong collinearity. R squared values were between 0.746 and 0.787, which indicates a good fit of the model.

Bootstrapping resampling procedure has been used to test the hypotheses in the model. Table 2 reports the results. Hypothesis 5 (Mission alignment -> vendor satisfaction) is shown to have the most significant relationship.

Hypothesis	Estimates	Support
Information Helpfulness-> Task Facilitation	.0366	No
Task Facilitation -> Vendor Satisfaction	.232***	Yes
Information Helpfulness -> Mission Alignment	.035	No
User Friendliness -> Mission Alignment	-.103	No
Technical Support -> Mission Alignment	.068	No
Task Facilitation -> Mission Alignment	.778***	Yes
User Friendliness -> Task Facilitation	.137	No
Mission Alignment -> Vendor Satisfaction	.620***	Yes
Technical Support -> Task Facilitation	.396***	Yes
Note: Path significance: ***p < .01, **p < .05.		

**Table 2. Hypotheses-testing Results.**

Multi-group analysis was conducted to test the difference between the cloud-based and in-house EHR solutions. As shown in table 3, the cloud-based group saw three significant relationships and one marginally significant relationship, but the in-house group had only one that was marginally significant. In particular, the relationships involving task facilitation as the dependent variable and the relationship between mission alignment and vendor satisfaction were stronger in the cloud-based group than in the in-house group. The results provide some support that cloud-based solutions were perceived as more conducive to task accomplishment and more mission aligned than in-house solutions.

Hypothesis	Cloud-Based	In-house
Information Helpfulness-> Task Facilitation	-1.591	0.031
Task Facilitation -> Vendor Satisfaction	-0.276	.354
Information Helpfulness -> Mission Alignment	0.054	0.430
User Friendliness -> Mission Alignment	0.118	0.051
Technical Support -> Mission Alignment	0.156	0.484

Task Facilitation -> Mission Alignment	0.624	0.056
User Friendliness -> Task Facilitation	0.883**	0.767
Mission Alignment -> Vendor Satisfaction	1.148**	0.550
Technical Support -> Task Facilitation	1.704**	0.158
Note: Path significance: ***p < .01, **p < .05.		

**Table 3. Multi-group Analysis Results.**

## Conclusion and Implications

This study examines how the characteristics of the EHR system (depicted by the user friendliness), the information that the EHR system produces helpfulness, and the technical support affect the healthcare's organizations task facilitation and mission alignment. In addition, this study investigates how these factors affect the healthcare organization's satisfaction with the EHR system that it adopts. The study also compares the cloud based EHR and the in-house based and how their results differ. Technical support of the cloud based EHR systems is a more powerful factor that positively affects the task facilitation. The theoretical framework combines the IS success model and the task technology fit theory for better understanding of user perceptions of this kind of health information systems. The research model identified the related factors that affect the organization's satisfaction with the vendor and hypothesizes the relationships. This study helps researchers and managers to best understand the cloud services features that are needed for their organizations, since it is planning to be tested empirically using information from actual medical organizations. Additionally, most studies focused on testing user satisfaction with the technology itself, however, vendor satisfaction, which is measured in this study, is a more comprehensive and relevant factor, because focusing on the technology alone could not be enough. Other factors such as cost and technical support are important to be considered and evaluated.

In this preliminary pilot study, around half of the hypothesized relationships were not supported. The reason probably could be the limited sample size. In the future, a larger number of observations from actual organizations will be collected. The California HealthCare Foundation reported that small or solo practices or community-based clinics are less likely to adopt EHRs and electronic prescribing than physicians working in large health organizations (Lorenzi et al. 2009). As a result, future research could study other independent variables such as organization's size, or location (e.g. rural areas) that affect moving EHR system to the cloud.

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