

Factors Influencing the Adoption of Cloud Computing by Saudi University Hospitals

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Abstract—This study aims to evaluate the adoption of Cloud Computing in Saudi university hospitals and to investigate the factors that impact the adoption. This study integrates the Technological, Organizational, Environmental (TOE) framework and the Diffusion of Innovation (DOI) theory, and adds the decision maker context to the original model. The study sample included Saudi university hospitals in Riyadh city. The data were collected using semi-structured interviews and a questionnaire. The result of this study determines the five most significant factors influencing the adoption of cloud computing in Saudi university hospitals, which are in sequence: Relative advantage, Decision-maker's innovativeness, Decision-maker's knowledge in IT, Compatibility, and Top management support. Moreover, among the four different contexts, the most important context is the Decision-maker context, followed by the Technological context, then the Organizational context, and finally the Environmental context. The findings are beneficial for hospitals to guide them to make better decisions regarding cloud computing adoption. Scholars can use this study to gain a more holistic understanding of cloud computing adoption and apply new theories in this field.

Keywords—cloud computing; (TOE) framework; (DOI) theory; technological innovation; IT adoption; healthcare; Saudi hospitals

I. INTRODUCTION

Cloud computing is one of the newest paradigms which allow cloud service providers to house cloud services and cloud-based resources in their data centers. According to [1] cloud computing in the coming years will be the fifth utility after electricity, water, telephone, and gas. The International Organization for Standardization (ISO) and the International Electro-technical Commission (IEC) define cloud computing as “a paradigm for enabling network access to a scalable and elastic pool of shareable physical or virtual resources with self-service provisioning and administration on-demand” [2].

Cloud computing is now considered one of the commonly deployed services due to its relative advantages for organizations, firms, and enterprises. According to [3], cloud computing entails four main service deployment models. The models differ according to the foundational infrastructure layer and the physical infrastructure. These models are private cloud, community cloud, public cloud, and hybrid cloud. Most definitions of cloud computing also state that cloud computing provides three major service models: Software as Service (SaaS), Platform as a Service (PaaS) and Infrastructure as a Service (IaaS) [3, 4, 5].

In the healthcare industry, due to the complexity of the Hospital Information System (HIS), many hospitals are considering shifting from traditional systems to modern mobile-based technologies. Cloud computing provides a solution to incorporate these technologies and use new forms of IT outsourcing [6]. There is a high demand for cloud solutions in hospitals to support greater sharing and accessibility of health data [7]. Different healthcare organizations adopt some types of cloud services in order to meet their needs and to improve quality of services [8]. Adoption of cloud computing can support hospitals in storing and sharing information such as Electronic Health Record (EHR). Cloud opens up a new horizon for patients' digitized health information that accessible via a secure authentication [7]. Health information such as medical histories, blood types, test result, and X-rays can be efficiently shared and accessed by physicians and clinics anywhere anytime. This in turn, enables hospitals to obtain diagnosis and recommendations to make the right dissection and treatments [9]. In addition, patient care can be improved when physicians remotely review the latest results in real time [10]. Moreover, scan images can be shared via cloud platform immediately with top specialists around the world to provide diagnosis and recommendations [7]. Collaboration over the cloud between physicians, patients, and the hospital is very important to improve patients' quality of service [11]. Furthermore, with cloud solutions, there is no need for buying expensive hardware and software licenses because all processing is controlled by the cloud provider [9]. Cloud computing will help health care providers to reduce the expenses of maintenance and IT staff [11].

However, a study in USA indicated that the adoption of cloud computing in healthcare industry is the slowest compared to other industries [12]. Reference [13] also revealed that only 4% of cloud customers in the USA are healthcare organizations. In Saudi, the adoption of cloud computing in many different organizations is also still low [14]. Some hospitals in Saudi Arabia still use paper-based records system in some of their departments [15, 16, 17, 18]. These findings explain the low and slow adoption of cloud computing in Saudi healthcare industry. This is because the electronic health systems serve as a foundation for the adoption of cloud computing solutions in Saudi hospitals. This problem encourages researchers to highlight the factors behind the slow adoption rate of cloud services by hospitals. In looking for reasons for such slowness in the adoption of cloud

computing in healthcare industry, researchers attributed that to the lack understanding of different factors related to the individual (CEO's characteristics), organizational, technical and environmental factors [19, 20, 21]. Thus, it is important to fill the gap related to the lack understanding of these factors affecting the cloud computing adoption in healthcare industry. As many researchers have identified some factors in different industries and countries [14, 19, 22, 23, 24, 25], this study focuses on investigating the factors affecting the adoption of cloud computing by Saudi university hospitals. Therefore, this research attempts to provide answers to the following research questions:

- 1) To what extent the decision-maker context influences the cloud computing adoption by Saudi university hospitals?
- 2) To what extent the technological context influences the cloud computing adoption by Saudi university hospitals?
- 3) To what extent the organizational context influences the cloud computing adoption by Saudi university hospitals?
- 4) To what extent the environmental context influences the cloud computing adoption by Saudi university hospitals?

Thus, this research attempts to achieve the following objectives:

- 1) To identify the factors that affect the adoption of cloud computing by Saudi university hospitals.
- 2) To develop a new framework with its own variables through modifying the original (TOE) model by integrating it with the (DOI) model and adding the decision-maker context.

In the following, this research develops the theoretical framework for cloud computing adoption by Saudi university hospitals, followed by research methodology and the research results which discussed with respect to the literature of adopting cloud computing.

II. THEORETICAL FRAMEWORK

As the purpose of this study is to examine the cloud computing adoption by Saudi hospitals, the theories and models at the organizational level are more applicable. In review of the technological innovation theories such as Institutional Theory, Theory of Planned Behavior (TPB), Technology Acceptance Model (TAM), Technological-Organizational-Environmental Framework (TOE), and Diffusion of Innovation Theory (DOI) in healthcare industry [20, 21, 26, 27], and of cloud computing adoption [14, 19, 28, 29, 30, 31, 32, 33, 34], the researcher found that the (TOE) framework which developed by Tornatzky and Fleischer [35], is a suitable framework for the study (see Figure 1). Based on this framework, there are three contexts influencing the technology innovation process, which are:

- **Technological context:** includes the technologies that are currently and internally used within the organization, in addition to the external and obtainable ones accessed by the organization.
- **Organizational context:** includes several organization constructs such as size, scope, and managerial structure.

- **Environmental context:** includes all the factors related to the environment in which the organization exists and operates such as industry and competitors.

These three contexts present both constraints and opportunities for technological innovation. The (TOE) framework is an organisational-level theory that provides a multi-perspective framework by including both internal and external factors. (TOE) is like a taxonomy for classifying factors, not only describing them. The main contribution of this framework is that it gives the researcher a free space to classify attributes under each context in a broad realm. The factors under each context usually were selected from previous studies which were found suitable with the condition of each study. Therefore, (TOE) has been the choice of many studies in IT adoption [36].

After reviewing the literature, the researcher found that (TOE) framework should be combined with other theories in order to identify specific factors. Integrating (TOE) with other models offering a large number of constructs and provides a richer theoretical base to understanding the adoption behavior [37, 38, 39]. Thus, this study integrates Diffusion of Innovation Theory (DOI) which is the main theory that commonly used together with the (TOE) framework. This is because these two models complement each other in term of that including the knowledge of innovation characteristics. Specifically, they explain the inter-organizational level instead of the only individual level such as (TAM) and (TPB) [40]. As such, this study adopted three factors from (DOI), and put them under the Technological context. These factors are relative advantage, compatibility, and complexity [41]. While the basis for the selection of the organizational and environmental factors have been made based on previous literature. This is the advantage of TOE framework that encourages the researcher to identify several factors in respect to each context. However, the researcher reviewed the most frequent factors that were chosen by many empirical types of research due to its significance in cloud computing adoption. Then, adopted the top management support, organizational readiness, and perceived barriers under the organizational context. In addition to the regulation and rules, and the competitive pressure under the environmental context (see Table 1).

The current study also relates to the Thong's model [42] that calls for the inclusion of the decision maker characteristics in combination with the technological, organizational, and environmental contexts. Thong distinguished decision-maker characteristics from the organizational characteristics. This context has been classified as decision-maker context. Thong believes that the IT adoption depends largely on both of the decision makers' feelings and functions that reflect the attitudes, motivations, and perceptions towards innovation adoption. Decision makers are responsible for making the most critical decisions. Therefore, In agreement with the significant role played by the decision maker, this study adds the Decision-maker context as a fourth dimension besides (Technological, Organizational and Environmental contexts), with the most investigated

factors like decision maker's innovativeness, and their knowledge in IT. Figure 1 illustrated the proposed model, which integrated and developed its own variables that identified as suitable for the cloud computing adoption by hospitals.

TABLE I. OPERATIONAL DEFINITIONS OF VARIABLES

Variables	Definitions
1. Decision-maker's innovativeness	It is defined as the level of decision maker's preference to try solutions that have not been tried out, and therefore are risky [42].
2. Decision-maker's knowledge in IT	The knowledge that is important to realize the advantages of new IT adoption. Knowledge proposed by the owner manager can add value to the organization [42].
3. Relative advantage	The degree to which the innovation appears superior to the previous versions [41].
4. Complexity	The extent to which the innovation is viewed to be consistent with the current trends and needs of the adopters [41].
5. Compatibility	The degree the innovation is perceived to be easy or difficult to use and understand [41].
6. Top management support	It refers to the top managers' support through sponsoring initiatives and engaging to adopt new technology in the organization [19].
7. Organizational readiness	It depends on the IT infrastructure and the IT human resources that the organization has to invest in cloud computing [19, 33]
8. Perceived barriers	It is the suitability of innovation to the organization in terms of security and other obstacles [33].
9. Regulations and rules	It refers to "the policies, initiatives, agencies, and everything that is provided or organized by the government to accelerate the rate of adopting a techno-innovation" [35, 19].
10. Competitive pressure	It refers to "the level of pressure felt by the firm from competitors within the industry" [40]

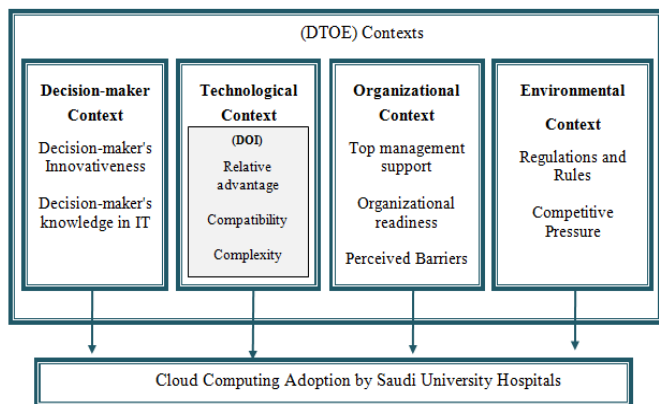


Fig. 1. DTOE framework used in this study

III. RESEARCH METHODOLOGY

The theoretical model followed during this study is the (DTOE) framework. In order to answer the research questions and meet the objectives of this study, a combination of qualitative and quantitative methods was used. With the purpose of exploring the impact of such (DTOE) factors, initial empirical work using interviews was deemed appropriate, as it can provide an in-depth insight from the IT managers' perspectives. The quantitative methodology was developed to gather numerical data in order to generalize findings [43]. The quantitative instrument used in this study is the questionnaire. It was written carefully to include all the sub-questions that represent the effect of each context (Decision maker, Technological, Organizational and Environmental) on the adoption of cloud computing by Saudi university hospitals. A total of 55 items was developed to measure ten factors in the theoretical model using a 5-point Likert-scale. Testing for reliability has been achieved by calculating Cronbach's alpha. All the constructs were found to have an adequate alpha (>0.6). Validity has also been assessed during questionnaire testing using factor analysis. The population of this study targets the Saudi university hospitals in Riyadh city, which includes King Khalid University Hospital, National Guard Hospital, King Khalid Eye Specialist Hospital, and King Abdul-Aziz University Hospital. The participants are the IT managers and heads of IT departments since they had the ability to understand the current situation of their hospital and future trends. In addition, the sample included the IT staffs who are the key of the cloud computing implementation team. (See Fig. 2). Data collection was conducted from October to December in 2015. The researcher received 120 usable questionnaires with response rate 75.47%. Several statistical measures are used for data analysis, such as Frequency, percentage, Mean, Standard deviation, Pearson, Analysis of variance (ANOVA) and Sidak tests. The following section presents the result of analyzing the factors affecting the adoption of cloud computing by Saudi university hospitals.

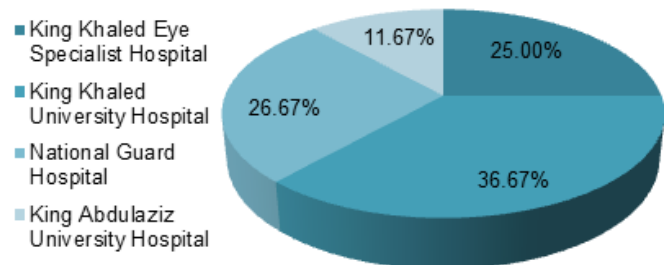


Fig. 2. Distribution of the study sample according to the hospital

IV. FINDINGS AND DISCUSSION

The results of the study indicate that the five most significant factors that influence the cloud computing adoption by Saudi university hospitals are in sequence (Relative advantage, Decision-maker's innovativeness, Decision-maker's knowledge in IT, Compatibility, and Top management support). Among four different contexts, the most important context is the Decision-maker context (mean = 3.90), followed by the Technological context (mean = 3.68), then the

Organizational context (mean=3.38), and finally the Environmental context (mean = 3.03).

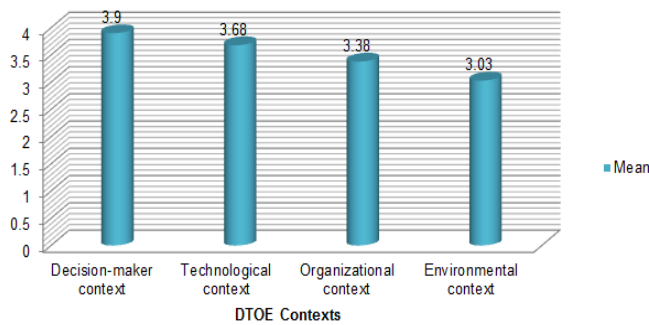


Fig. 3. Affecting the (DTOE) contexts on the adoption of cloud computing by Saudi University Hospitals

A. Decision-maker Context

This context represents the personal characteristics of the decision makers in Saudi university hospitals. The two variables included in this context were Decision-maker's innovativeness and Decision-maker's knowledge in IT.

Unexpectedly, the results showed that this context was the most significant among the four contexts. Further, both Decision-maker's innovativeness and Decision-maker's knowledge in IT were positive factors, and they ranked second and third in sequence among the 10 variables. This finding revealed the importance of the innovative decision-maker in introducing new IT services in Saudi hospitals. Results also indicate the decision maker's positive attitude towards the adoption of cloud computing. The results showed the decision makers' willingness to increase their knowledge in the advanced technologies that become trends. Due to their central role, it seemed that they were responsible for introducing such technology into their hospitals. These results are supported by Thong's finding [42] that the adoption of IT innovation depends on both of the decision makers' feelings and functions that reflect the attitudes, motivations, and perceptions towards innovation adoption. The interviewees in Saudi university hospitals have an obvious interest in translating to the latest services and technologies that support hospital's operations and help the patients as well. The cloud computing was their choice to develop the current state and take their hospitals to a high level of quality and production.

Therefore, hospitals should take into account the personal characteristics of the decision makers. This is because the rate of organizational change is highly related to the ability and capacities of managers to accept this change. Reference [44] affirms the same idea, stating that the resistance to change by the decision makers is one of the key barriers to adopting innovations by organizations.

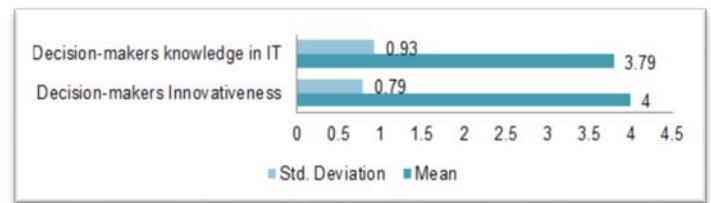


Fig. 4. The participants' responses to the Decision-maker context

B. Technological Context

This context represents three technical variables obtained from (DOI). The relative advantage was the first significant factor affecting the cloud computing adoption by Saudi university hospitals among ten variables. Results showed that the relative advantage had a positive effect. This implies that the participants of this study believe that cloud computing is very beneficial in providing dynamic and high service availability. It also implies that cloud computing is helpful to their hospitals to improve the quality of medical services. This result is consistent with the study conducted among U.S. industries [19]. Reference [29] also supports this result by showing the positive effect of adopting cloud computing in small businesses in Arizona. Furthermore, the relative advantage was the most critical factor that affected the adoption of public cloud by U.S. hospitals [20]. The interview result is also aligned with the same context, the main relative advantages that encourage the Saudi university hospitals to move to the cloud were are data centralization, quick response, ease of use in operation and maintenance, lower cost, and reducing the risk of IT infrastructure failure. On the other hand, the relative advantage was found to have a negative effect on the cloud computing adoption by high-tech industry in Taiwan [45]. In addition, some other studies on cloud computing adoption for instance, references [33, 34] showed that the relative advantage did not have a positive or negative impact.

As for complexity, it was found to have a neutral effect. This means that complexity neither has a positive nor a negative effect on the adoption of cloud computing by Saudi university hospitals. This result suggested that the complexity factor could have played role in influencing cloud computing adoption in this research but not a challenge. It is worth noting that this result reverses the participants' technical background that can help them to pass the complexity of such technology. It also shows their readiness to learn any new technology such as cloud computing. Inconsistent with previous adoption studies in healthcare, complexity was the most critical factor that affected the adoption of public cloud by U.S. hospitals [20]. It was also the fifth of the most critical factors affected the decision to adopt cloud computing in Taiwan hospitals' industry [21].

As expected, compatibility was one of the most critical factors affecting the adoption of cloud computing by Saudi hospitals. It ranks the fourth among 10 variables. This is consistent with previous studies in terms of its significant impact on the adoption of cloud computing [19, 29]. It was also found to be a positive significant factor in the adoption of cloud computing by organizations in Saudi Arabia [14, 34]. However, this result is inconsistent with a study conducted in the high-tech industry in Taiwan that indicates that compatibility does not have an effect on the adoption decision [45]. One possible explanation for the positive effect of compatibility is that it is assessed in the early stage before taking the adoption decision of cloud computing [21]. According to [19] compatibility was the first contributing factor affecting the cloud computing adoption in U.S. industries. In this study, the positive effect of cloud computing decision with the hospital's business strategy, IT infrastructure, and operations received high agreement by the study's participants. This particularly proves that the adoption of any technology needs to make sure that current systems and infrastructure are compatible with the new technology. It is worth noting that the IT manager of King Abdulaziz University Hospital (KAUH) commands in this regard the following "we are very concerned about the compatibility and the consistent of cloud computing adoption with the current systems and hospital's operations".



Fig. 5. The participants' responses to the Technological context

C. Organizational Context

This context includes three variables representing the characteristics of an organization. Top management support is perceived as significantly important in this study. It ranks the fifth most critical positive variable among 10 variables. This finding is crucial as it indicates that cloud computing in Saudi university hospitals receives strong support from top management. Specifically, it is considered as strategically important. This attitude of top management in Saudi university hospitals is acutely promising. It shows that the top management provides an essential motivation for the successful introduction of the cloud innovation. The result of this study is consistent with previous studies. For example, it

is similar to the studies conducted in Saudi organizations and Taiwan hospital industry that considered top management support as the most important factor in the cloud computing adoption among other factors [21, 34]. It was also found to be the most significant factor through the IT managers who were interested in adopting cloud computing in different U.S. industries [19]. Top management support was also found to have a positive effect on the decision to adopt cloud computing by high-tech firms [45].

In this study, organizational readiness has a neutral effect. This is related to the medium level of sophistication of the technical resources, in addition to the financial resources that can be used to adopt cloud computing. This result goes in line with previous studies in which organizational readiness had a medium or small contribution in the adoption of cloud computing [19, 34]. The survey result is also consistent with the interview with the IT managers in Saudi university hospitals in terms of that, the hospitals would be changed as groups of users and types of systems will be added. They stated that the change required for introducing cloud computing in hospitals is not a simple task but also not complex.

Unexpectedly, survey result shows that the perceived barriers have a neutral effect on the adoption of cloud computing in this study. While the security and privacy issues were the most important factors behind the adoption of cloud computing in previous studies [14, 22, 28, 31, 34]. Trust of cloud vendors was also the key factor to accept cloud computing [32]. This is particularly true for hospitals due to the sensitive data stored in the cloud. Security is perceived as remarkably important in the health care industry [21, 27]. However, the result of this study indicates a moderate level of participants' awareness regarding these major issues. On the other hand, the interviews' result shows a serious concern toward data security, privacy, confidentiality of patient data, and vendor's lock-in. For this reason, all of them are planning to implement a private cloud. This result is aligned with the previous studies and it clearly reflects the attention of the top management and decision makers regarding such big issues.



Fig. 6. The participants' responses to the organizational context

TABLE II. OVERALL ANALYSIS OF THE RESEARCH VARIABLES

Context	Context Ordinary	Variable	Mean	SD	Ordinary
Decision-maker context (mean=3.90)	1	Decision-maker's innovativeness	4.00	0.79	2
		Decision-maker's knowledge in IT	3.79	0.93	3
Technological context (mean=3.68)	2	Relative advantage	4.15	0.81	1
		Complexity	3.37	1.04	6
		Compatibility	3.51	0.86	4
Organizational context (mean=3.38)	3	Top management support	3.50	0.91	5
		Organizational readiness	3.35	0.97	7
		Perceived barriers	3.30	0.93	8
Environmental context (mean=3.03)	4	Regulations and rules	2.92	0.99	10
		Competitive pressure	3.14	0.89	9

D. Environmental Context

This study shows that neither regulations and rules nor competitive pressure has a positive or negative effect on cloud computing adoption by Saudi university hospitals. These two variables came last (ninth and tenth) among all variables. The mean of environmental context (3.03) is also relatively low compared to other contexts. This means that the inside requirements of (technical, organizational, and the attitude of the decision maker) are considered more important than the outside pressures. These findings are both expected and consistent with some of the previous studies. Although competitive pressure had a strong positive effect on adopting cloud computing in the high-tech industry in Taiwan [45], it was not found to be a factor influencing the adoption of cloud technology in Saudi [34]. Similar to the findings by reference [44], reference [19] states that firms will respond more quickly and implement changes in the competitive environment. In contrast, regulatory concerns have a negative effect on the adoption of cloud technology in the government sector in Saudi Arabia [22]. The differences in the effect of the environmental factors among the previous studies might be related to the competitive environment, in addition to the varying policies and regulations in each country. Consequently, this context ranks the last affected context among the other four contexts. This result is consistent with the study conducted in Taiwan hospital industry that shows that the environmental factors are not critical [21].

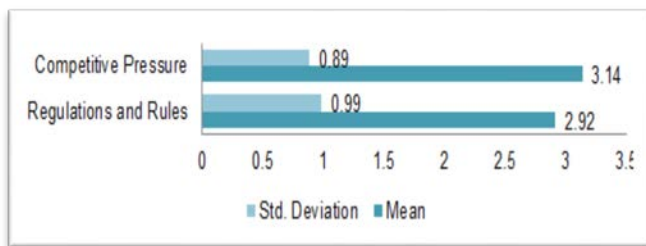


Fig. 7. The participants' responses to the Environmental contexts

In general, based on the proposed model, Table 2 and Figure 8 show the overall analysis of affecting the research variables on the cloud computing adoption by Saudi University Hospitals.

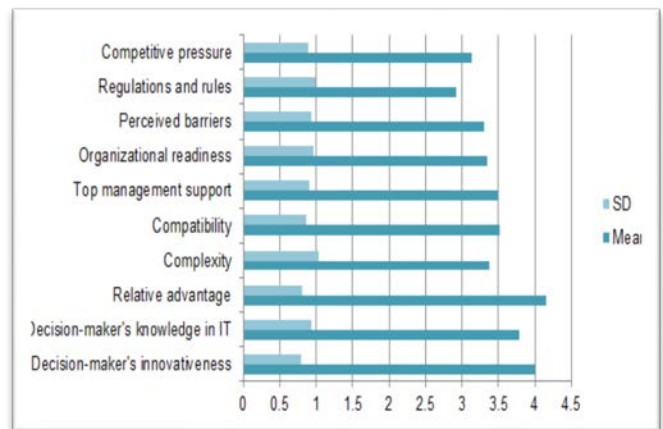


Fig. 8. Affecting the research variables on the adoption of cloud computing by Saudi University Hospitals

V. CONCLUSIONS

The aim of this study was to examine and evaluate the adoption of cloud computing by Saudi university hospitals. Specifically, the problem researched in this study was the lack understanding of the factors influencing the adoption of cloud computing by Saudi hospitals. This study integrates the (TOE) framework and (DOI) theory, and then adds a new context called decision-maker context. The study reveals that all of the Saudi university hospitals in Riyadh city are at the planning stage to adopt cloud computing services. The result obviously reflects the crucial effect of the decision makers on making the adoption decision of cloud computing. It also shows their positive attitude in translating to the latest services and innovation. The most important context in this study is the decision-maker, followed by technological, then organizational, and finally the environmental context. The study investigated ten variables among the proposed research framework. The five most critical factors for adopting cloud computing by Saudi university hospitals are in sequence (relative advantage, decision maker's innovativeness, decision maker's knowledge in IT, compatibility, and top management support). The main contribution of this study is the implications drawn from the results for hospitals and academia. For hospitals, this study identifies the key factors

influencing the adoption decision of cloud computing. The findings can guide them to make better decisions in this regard. For academia, this study adds to the knowledge in the field of cloud computing. Researchers can depend on this study result in conducting new studies and applying new theories in this field.

VI. RECOMMENDATIONS

The results of this study provide ideas for further research in the field of cloud computing adoption by healthcare industry. This part presents the recommendations for future research and practical ideas for cloud computing adoption in Saudi hospitals.

- This study should be extended to adopt cloud computing in public and private hospitals in Saudi Arabia. Each category of hospitals has different policies regarding the adoption and access to different resources of cloud computing.
- It is recommended to explore the impact of other critical factors within the four contexts of the (DIOE) framework on cloud computing adoption by hospitals. It is also recommended to explore the factors investigated in the area of cloud computing adoption by other researchers, e.g., reference [26, 27].
- As the population of this study is limited to university hospitals, the researcher recommends future quantitative studies to include population representing all public hospitals, a category not covered in the present study.
- More future quantitative studies are recommended to be conducted on similar topics to provide a better understanding of the critical factors affecting the adoption of cloud computing by Saudi hospitals.
- Services of cloud computing should be surveyed and developed in Saudi private and public hospitals.
- Procedures and initiatives should be taken to adopt and exploit the massive advantages of cloud computing applications in Saudi hospitals to improve the quality and management of healthcare services.

VII. FUTURE STUDIES

Based on the significant results of this study, the following suggestions could be made for future studies:

- Conducting a case study in Saudi hospitals to analyze qualitatively how different influential factors can affect the adoption of cloud computing.
- Conducting cross-country comparisons to identify variance that occurs according to the healthcare industry environments.
- Investigating and evaluating the adoption of cloud computing services by the Saudi government and private hospitals.
- Examining issues of data security in Saudi healthcare sector.

- Examining factors associated with adoption healthcare records in Saudi government hospitals.
- Examining to what extent cloud computing increase business value in Saudi government and private hospitals.

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