# *Evaluating the Hospital Information System Success in Riyadh Tertiary Hospital, Saudi Arabia*

A Thesis

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## Abstract

***Background*** Adoption of HIS in healthcare aimed to elevating efficiency, reducing costs, and improving quality of care through managing medical and administrative information. Systematic evaluation of HIS effectiveness became a fundamental requirement for healthcare transformation. It is hoped that this study will provide an insight on HIS evaluation and its influence on healthcare providers performance through the adoption of the widely used system evaluation theory; DeLone and Mclean Information System (IS) Success Model, in healthcare context in Saudi Arabia.

***Objective*** to Identify the HIS adoption success factors and assess the influence of these factors on healthcare provider performance.

***Method*** A descriptive cross-sectional study with a survey design carried out among healthcare providers working in a tertiary hospital with 500+ bed capacity and 2000+ employees in Riyadh Saudi Arabia. Convenient sampling was employed for data collection among selected healthcare specialties including physicians, pharmacists, nurses, laboratory technicians, and Radiology specialists / technicians. Due to the non-normal data distribution among responses acquired using convenience sampling, the Partial Least Squares-Structural Equation Modelling PLS-SEM was employed for data analysis.

***Results*** Reflective measurement model output assessment by convergent and discriminant validity testing were satisfied with required criterions. It was found that User Satisfaction had the highest positive effect on Individual Impact and the System Quality had positive effect on User Satisfaction. In the comparison of system influence on the different healthcare provider specialities, radiology specialists/technicians scored the highest performance on effective use of HIS which mean that they are the most effective user of HIS with the strongest performance.

***Conclusion*** All the statistical test results confirmed the validity of the research model as an IS success framework in healthcare. The model output confirmed that the proposed system quality, information quality, user satisfaction, and effective use are the significant predictors.


***Keywords*** Health Information System, Healthcare providers; performance; information system

evaluation. System quality characteristics, information systems success.

# 1. Introduction

## 1.1 Background and Rationale

Early in the 2000s, the Institute of Medicine (IOM) released two reports that introduced a dramatical changes toward improvement in healthcare practice since after(1). In addition to the alerting highlights about medical errors and patient safety in health care in the U.S, reports highlighted imperative recommendations for innovation and redesigning of the healthcare system to improve quality of care and patient safety(1). One of the focus points included in the reports was the suggestion of making the effective use of information technology as one of the essential strategies for healthcare redesign(2).

Health care is an information-based practice(3) which makes the Information management technologies considered as a fundamental element of healthcare delivery system(1). Clinicians needs to review timely, accurate and an updated health information about their patients to be able to provide high quality of care(4). Information technology such as Electronic Health Records (EHR) and computerized provider order entry (CPOE) may considered critical to the transforming of Healthcare(5).

Health Information System (HIS) could be defined as an electronic record of stored health-related information for an individual that can be accessed and shared between clinician and staff within one healthcare organization(6) to facilitate workflow and improve the quality of patient care and patient safety(6). Over the last years HIS became an evolving innovation in healthcare industry all over the world(7). The adoption of HIS has been expanded widely in healthcare organizations for the purpose of elevating efficiency, reducing costs, and improving the quality of patient care in addition of managing medical and administrative information(8)(9). It is known that more than 85% of hospitals have adopted HIS in both the United States and European Union countries(10)(11). In Middle East countries, there has been a significant progress in the adoption of E-Health services including HIS(12). In Saudi Arabia,

eHealth has been an emerging innovation in healthcare. In 1988, a notional plan was adopted to develop Information and Communication Technology (ICT) in healthcare sector and since after the field of eHealth have showed evidence of continual growth in the Kingdom(13)(14). Established strategic plan based on the vision of the Saudi Ministry of Health (MOH) has positioned eHealth as a primary transformation agent and enabler in healthcare in the Kingdom. in 2008, the government began the e-health project which was divided into 100 sub-projects, the HIS program entitled HIS strategy was one of the most significant sub-projects(15).

High cost and shortage of expertise in innovative systems in information technology were found to be main challenges in eHealth usefulness in healthcare in Saudi Arabia(16). In addition, multiple human factors were identified among the challenges (17). Major factors included shortage of health professional faculty who are familiar with hospital information systems and related technologies and shortage of health informatics specialists who can implement these technologies(17). Moreover, knowledge, experience, motivation, and training of healthcare professionals on using hospital information systems were identified challenges(17). However, although researches on eHealth is increasing in Saudi Arabia, further investigations on the views of stakeholders remains needed(16).

Health information system implementation usually attended with considerable investments and high expectations. The U.S. Congressional Office of Technology Assessment has estimated that computerized systems, when fully implemented, account for 4% to 8% of an institution's total operating budget(18). In Saudi Arabia, Healthcare sector hold the third largest share of around 16% in the budget expenditure of 2020(19). Information technology in the Kingdom became a core factor of upgrading the healthcare sector which comes in line with the government's Vision 2030 and the National Transformation Program (NTP).

Despite the facts that implementations of HIS in healthcare practices are largely recognized to support greater quality of care and higher efficiency in service delivery(3)(20), Studies shows that medical errors

could occur due to the incomplete data field of notes provided and multiple typing mistakes in the system which leads to patient dissatisfaction and impacting the quality of care(21). HIS use could negatively affect the performance of healthcare providers considering their task complexities and the overall work environment(21). In addition, implementation usually entailed changes in work processes, which creates more challenges for clinicians and staff in general. Human-computer interface was one of the dimensions found by the Joint Commission to lead to a high percentage of health information technology related serious adverse events were an unintended physical injury to the patient resulting from or contributed to by medical care (22).

Systematic evaluation of the effectiveness of Health Information System became a critical requirement considering the visible increasing cost of technology and the rapid technological changes. Despite the rapid increase in the adoption of Health Information system, existing research on its effectiveness and impact on healthcare practitioners performance remains limited(4). This study will provide insights for understanding the influence of HIS by addressing system potential success factors that will guide the decision making process for healthcare organization leadership.

# 2. Literature Review

## 2.1 HIS Adoption

HIS is an integrated information system that support hospital information requirements for daily operations(6). Literature have shown evidence for the potential benefits for using HIS in hospitals such as improving quality of healthcare services and enhancing the effectiveness and efficiency of healthcare providers(23). For these benefits and others, HIS adoption rates have been observed increasingly(11). In developed countries HIS have reached progressed level of implementation in hospitals(24). For instance, Europe countries such as UK, Australia, and New Zealand have reached advanced percentage of HIS adoption, although some other countries like Germany have delayed rates of adoption(25). In the U.S, health Information Technologies was placed at the heart of the Federal Government Program(26). The

Office of National Coordinator for Health Information Technology (ONC) was formed to coordinate the use and implementation of information technology in hospitals and physicians' offices(27). with the extended governmental initiatives, increased adoption of HIS in US hospitals have been observed although many of them have fail to achieve high level of functioning(26). Multiple challenges were identified in HIS adoption in the US and Europe countries. Such as lack of efficient technical infrastructure, user attitude and resistance to change, cost of implementation, and privacy concerns(25,26).

Despite the delay in adoption and use of HIS in hospitals of Middle East countries, during the few past years the governments of these countries have acknowledged the importance of information systems including HIS which resulted in significant increase in its adoption(12). In Saudi Arabia, the field of eHealth including HIS have showed evidence of continual growth(16). This growth was strongly influenced by the Healthcare Transformation Strategy plan established by the Ministry of Health (MoH) to counter challenges and elevate standards for healthcare services(28,29). Although HIS adoption was growing at different rates among country regions, implementation was faced with challenges that delayed HIS adoption(30). Such as IT infrastructure and information security which were identified by researchers as major challenges that requires large budget allocation(16). HIS has played a vital role in improving healthcare services in Saudi Arabia, literature demonstrated evidence for a wide range of benefits gained by implementation of HIS in Saudi Arabia hospitals such as improving the quality and efficiency of healthcare.

In hospital context, HIS is usually utilized by all sections and influence multiple aspects of the organization operations(31). Therefor evaluation of effective adoption is required to identify major barriers and motivating factors as well(32).

## 2.2 HIS Functionalities

Mostly, Hospitals in developed countries are using comprehensive HIS while in other countries paper –

based processes for medication orders and laboratory tests still in use(33)(7). The widespread adoption of HIS intended to reduce costs through improved efficiency and less minimizing effort duplication in service delivery(34). In addition, effectiveness of administrative and management processes required an integrated functionality of HIS. It is essential to define the core functions of HIS that should be adopted to maximize impact on quality and patient safety.

Based on the international hospital quality standards (35), Health Information System core functionalities may include:

1. **Health Information Management**

This function provides an integrated health record database that allows retrieval of patients' health information including medical histories, diagnosis, lab tests and reports, medications, clinical notes, by the authorized care providers.

2. **Workflow Synchronization**

The system must provide workflow management to simplify clinical processes efficiently.

3. **Communication**

System should enable the care providers to interact with each other electronically for better clinical decisions, time saving, and minimizing duplication of efforts.

4. **Clinical Support**

Reminders and alerts are an essential function in care process in addition of engaging patient in the care process.

5. **Data Exchange**

Enhanced system interoperability between applications at the different departments to support exchanging of clinical data in standardized secured formats among authorized healthcare providers.

**6. Administrative Tasks**

Incorporated billing, and scheduling features for improving service quality and customer satisfaction is essential to be supported by HIS functions.

## 2.3 HIS Evaluation Overview

Successfully implemented HIS has great benefits for healthcare professionals and healthcare delivery system(36), Such as improving information management, providing access of information to support healthcare professionals in addition to improving the patient's access to healthcare which will result in social and economic benefits(36).

When not efficiently implemented and used, HIS can have a negative impact on healthcare services(37,38). As an example; inappropriate training of the users may lead to absence or use of wrong information in medical decision-making which eventually will impacting the patient's general health(37). Management and evaluation of HIS is considered essential for determining the effectiveness and efficiency of use and to ensure the fulfilment of the high demands for continuity of safe, high-quality and cost-effective provision of healthcare(39,40).

In health informatics, evaluation can be defined as the act of assessing or measuring the properties of HIS during the system planning, development, or operation and maintenance to provide the basis for a decision to be made concerning that system in a specific context(41). Evaluation frameworks usually identify features or categories of HIS that will lead towards improvements to achieve better health outcomes and improve patient safety(42). In addition it will present lessons learned and more efficient strategies to improve HIS(43).

Different approaches have been developed concerning HIS evaluation. Generally it can be categorized into Formative and Summative(41). Formative evaluation is conducted during the system development and aims to improve the HIS based on user feedbacks. For instance, it can be conducted during rapid prototyping or system requirement specification assessment. While Summative evaluation aims to demonstrate clinical outcomes from HIS system use in clinical work or routine(44). Usually, Summative

assessment is executed after the system implementation to identify its effectiveness. Evaluation can also be subjective, constructed on personal assessments, or objective that is based on systematic assessments(45).

Despite that system evaluation may offer invaluable benefits to the decision-makers in healthcare organisations, there are multiple challenges have been addressed by technology evaluators(46).One of the major challenges is the complexity of the system and the motivation in performing the evaluation(46). In addition, multiple factors may influence system evaluation process other than the technical features of the system. Such as social, organisational and cultural factors (43). Other factors that can affect an evaluation is the context of the evaluation (use, communication, effectiveness or organization), the selected methodology (qualitative, quantitative or both), the different users/stakeholders that can be benefited from the system, and the objectives of the evaluation(43).

Based on evaluation objectives and selected variable, several evaluation models have been constructed to evaluate the quality of information systems. Some of these models have adopted a behavioural focused approach which is based on individual human behavioural processes associated with human computer interaction such as Technology Adoption Model (TAM)(47), Health IT Usability Evaluation Model (Health-ITUEM)(48). ISO Quality model(49). And DeLone and McLean IS success model(50).

Particularly in Saudi Arabia different evaluation frameworks were employed to identify barriers and evaluate effectiveness of eHealth applications including HIS. A systematic review study for HIS adoption barriers in Saudi Arabia was conducted based on the Technology Acceptance Model (TAM)(51). The study revealed that the lack of healthcare professionals' computer experience and familiarity with HIS are among the topmost frequently reported barriers. Another study was found for barriers and challenges in adopting Saudi Telemedicine Network(52) using three models; the Unified Theory of Acceptance and Use of Technology (UTAUT), the Technology Organisation Environment (TOE) theoretical framework, and the Evaluating Telemedicine Systems Success Model (ETSSM).

Some major barriers identified by this study are insufficient support and quality of basic facilities and ICT infrastructure, inadequate availability of experts, and lack of the ability to solve addressed challenges. Finally, some studies have assessed HIS use in Saudi Arabia without employing specific related model. In a study for electronic health records use and barriers in Eastern Province in Saudi Arabia(53), a generic evaluation approach were followed. There was no specific model identified but the study methodology was built on HIS functionalities. Loss of access to records transiently if computer crashes, additional time consumed for data entry, and loss of access to records transiently if computer crashes were some revealed barriers.

## 2.4 Knowledge Gap

In this research, assessment of the dimensionality of HIS success factors will be guided by the famous and mostly validated DeLone and McLean IS Success Model as an established model in several HIS evaluation studies(54). The need of this study could be demonstrated by the literature review for HIS evaluation studies in Saudi Arabia context. From the researcher point of view, a standing demand for a comprehensive evaluation of HIS in hospital context was observed. Although the number of eHealth publications is increasing, there remains the need to investigate the views of specific stakeholder groups towards eHealth(43). Further researches was recommended to be conducted on HIS evaluation due to the limited studies on the users' perception and adoption generally(55). Considering the acceleration in eHealth adoption in Saudi Arabia during the past few years, periodic assessment is highly required to assess the utilization of HIS in hospitals(53).

## 2.5 Theoretical Backgrounds

Assessing the influence of information system characteristics on individual impact were guided by several theories as part of system evaluation frameworks. One of the mostly adopted and validated theories is the DeLone and Mclean Information System (IS) Success Model (1992). The DeLone & Mclean model has been tested and validated in thousands of studies in the IS domain over the last 20 years(56). In their significant paper, DeLone & Mclean introduced a comprehensive taxonomy posits of

six major dimensions for IS success measures which are system quality, information quality, user satisfaction, use, individual impact and organizational impact. Based on the six dimensions, they reviewed a total of 180 conceptual and empirical studies and finally created their famous descriptive model Figure-1.

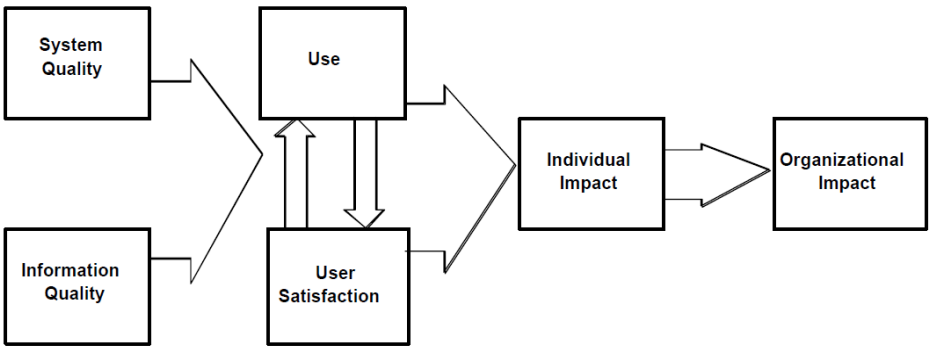


**Figure 1. The DeLone-McLean Model for IS Success**

In their paper, DeLone-McLean provide description of each dimension as follow:

***System Quality***: the measures of information system itself that reflects the engineering-oriented performance characteristics such as reliability of computer system, response time and ease of use.

***Information quality***: It reflects the content issues and characteristics of the information systems output. It can be measured through the system output or produced information characteristics such as degree of information relevance and completeness.

***Use***: can be defined as the manner in which an information system is used. The original DeLone & Mclean study included the Use since their theory is applied in voluntary context of using HIS not mandatory.

***Effective use*** is suggested to be an alternative measure for Use since multiple studies have pointed that measuring the use of an information system while it is mandated by most of the organizations will be pointless (57). In addition, due to the difficulty in interpreting the multidimensional aspects of "use"—

mandatory versus voluntary, informed versus uninformed, effective versus ineffective, and so on(56). Effective use denotes the achievement of accomplishing clinical tasks by clinicians without significant medical errors (58).

***User Satisfaction***: This construct can be reflected by measuring the overall user satisfaction which will be assessed by this study.

***Individual Impact*:** DeLone & Mclean characterized individual impact as an indication that an information system has given the user a better understanding of the decision context, has improved his or her decision-making productivity, has produced a change in user activity, or has changed the decision maker's perception of the importance or usefulness of the information system(50). In this study Individual impact will be indicated by performance of care provider and quality of patient care.

***Organizational Impact***: The effect of information system on the organizational performance. Many researches about measuring the influence of information system in healthcare didn't focus on the measures of Organizational performance. According to DeLone and Mclean, this is explicated by the difficulty of isolating the contribution of the information systems function from other contributors to organizational performance. (50). In addition, evaluating the system effectiveness from organizational performance prospective should include all stakeholders such as patients, vendors and external contractors which will be difficult to attain. Considering these facts, the organizational impact was excluded from this study.

## 3. Study Objectives

1. To Identify the HIS adoption success factors.
2. To assess the influence of system quality and information quality, on the effective use of HIS and user satisfaction.
3. To assess the influence of effective use and user satisfaction on the healthcare providers' performance.

4. Compare the performance of different healthcare providers with regard to effective use of HIS and their satisfaction.

## 4. Research Questions

1. What are the factors used to measure the success of HIS system adoption in the health care setting?
2. To what extent do system quality and information quality influence the effective use of HIS and user satisfaction?
3. To what extent do effective use and user satisfaction influence the performance of health care providers?
4. How does the performance of different healthcare providers are compared in terms of effective use and their satisfaction?

## 5. Research Model and Hypothesis

The questionnaire adopted is structured based on the original DeLone and Mclean Information System (IS) success model. The model suggests six interrelated constructs of information systems success measures, that are, system quality, information quality, user satisfaction, use, individual impact and organizational impact. The causal - explanatory model assumes that system quality and information quality, separately and mutually, affect both user satisfaction and use. It also suggests that amount of use and degree of user satisfaction may negatively or positively alter each other. and presumes them to be direct antecedent of individual impact, and this impact on individual performance should have some organizational impact. The DeLone-McLean model can be interpreted as a predictive one for how the preceding variables help to predict the dependent variables which is worth to be tested empirically. Based on that, this study proposes to test the hypotheses reflected in Figure – 2. Which are the following:

***H1****: System quality is positively associated with effective use*

***H2****: System quality is positively associated with user satisfaction*

***H3**: Information quality is positively associated with effective use.*

***H4**: Information quality is positively associated with user satisfaction*

***H5**: Effective use is positively associated with user satisfaction*

***H6:** Effective use is positively associated with individual impact*

***H7**: User satisfaction is positively associated with individual impact*

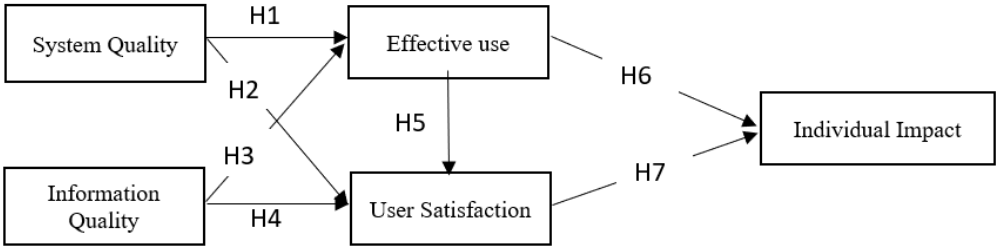


**Figure 2** – Research Model

# 6. Research Method

## 6.1 Study Design and Duration

A survey research design was adopted in this cross-sectional study. Cross-sectional research collects quantitative data at a single point; this approach is usually employed to examine multiple variables when testing proposed hypotheses and answering research questions(59). In this study the questionnaire was structured to collect quantitative data by selecting appropriate questions from previously validated survey instruments. The study was conducted over a period of three months.

## 6.2 Study Setting

The study took place in Riyadh Saudi Arabia in a private tertiary hospital that have an Outpatient and Inpatient services with 500+ bed capacity and 2000+ employees with diverse nationalities. The hospital

was established in 2000 using paper-based system, a form of electronic hospital information system was initially implemented in 2005. and since after the organization applied multiple updates on the system versions which included new features but with no major changes in most of the system clinical applications. The HIS functions include Computerized Physician Order Entry (CPOE) and an embedded Clinical Decision Support system (CDSS). System integration have been established with existing systems in the hospital at different areas of practice such as Radiology and Laboratory department. A recent update in the hospital HIS version included an advanced feature on clinical documentation. With each version updates implementation phase, a comprehensive user training courses were conducted to all users. The hospital healthcare services include Rehabilitation, Ambulatory care and Surgical services.

## 6.3 Ethical Consideration

IRB approval and access of data were secured from the hospital and had been taken prior to initiatng the study (IRB Approval number: 15-2020-IRB). Applicants were assured of full confidentiality and all information kept anonymous and for research purposes only.

## 6.4 Sample population and Sampling Technique

The target population of this study is healthcare providers who are working in a private tertiary hospital in Riyadh Saudi Arabia under clinical aspects of healthcare services and they are an active user of HIS. The hospital was selected to conduct the study since it is the working hospital for the researcher for who have been present during the multiple transformation of the hospital information system. The sample population is difficult to reach as clinicians due to their hectic schedule which may discourage them from participating in the study and limit the use of random sampling. In addition, the relative cost and time required to carry out a convenience sample are minor in comparison to random sampling techniques(60). For these reasons, Convenience sampling was selected as the most appropriate and practical sampling technique for this study. Convenience sampling is conducted by selecting individuals or groups of samples from a group of population who are conveniently available and willing to participate in the research(61).

The sample included physicians, pharmacist, nurse, laboratory technician and Radiology specialist / technician. Selected healthcare providers had some similarities in their system usage practices in addition of some shared system processes such as medication orders and administration process which involve physicians, pharmacists and nurses. Convenient sampling technique has been applied by visiting multiple location for each type of healthcare providers such as pharmaceutical care department, Physician's offices and multiple inpatient admission units. Then applicants were selected based on their availability and willingness to participate.

## 6.5 Sample Size Estimation

To estimate the sample size needed, a power analysis was conducted in G*Power using the linear multiple regression statistical test as recommended by Hair et al.(62)(63) criterion was considered to be the main guideline to calculate the effect size $f^2$ (0.02 = small, 0.15 = medium, 0.35 = large). The recommended sample size for this research was n = 129 ($f^2$ = 0.15, $\alpha$ = 0.05, power = 0.95, number of predictors = 4) to achieve a statistical power of 0.95.After performing data cleansing by removing 25 responses with unengaged responses (respondents answered the same scale for every measuring variables) in SPSS, 290 sets of questionnaires were useable for further analysis, which was above the required sample size of 129.

## 6.6 Inclusion Criteria

The following Inclusion Criteria were applied for selecting applicants for this study:

- Age range include 23 and above
- Average years of experience in using the HIS in the organization is 1-5 year
- Male and female staff
- All nationalities are included
- Active users of HIS with operational tasks

## 6.7 Data Collection

Data were collected randomly from the applicants who have met the inclusion criteria that have been mentioned above by using self-administered Questionnaire. A Total of 500 paper-based questionnaires had been distributed to ensure sufficient responses for the required sample size. In addition, a soft copy link for the study questionnaire was structured using Google Forms application and it was used to collect data for some physicians (surgeons) due to their limited available office times and the nature of their schedules which was different from other physicians. The questionnaire link was sent to their work emails and their responses were received automatically through the application. Data collection was conducted over three months period, from January to March 2020.

## 6.8 Selected Statistical Analysis

In addition to the Descriptive statistical analysis used to describe observation of data collected for the demographic characteristics of study applicants, Partial Least Square Structural Equation Modelling PLS – SEM was employed for data analysis in this study including the following tests:

1. Reflective Measurement Model Analysis
2. Structural Model Analysis
3. Importance Performance Matrix Analysis (IPMA)

Further explanation on the rational of selecting these analysis techniques are included in the Results section.

## 6.9 Instrument

For the data collection, a questionnaire was developed and based on selecting appropriate questions from validated survey instruments with minor modifications. Despite the availability of validated instruments, unfit study concepts and requirements in the measurement allow the addition, modification, or deletion of question items(50,56,57,64,65). To ensure validity the questionnaire was viewed by expert clinicians who represent selected sample which included Medical Affair Director, Nursing Director, Laboratory Manager, Head of Radiology department and Chief Pharmacist. The questionnaire contains six sections,

namely, Section A; applicant's demographic profiles, Section B; System Quality items, Section C; Information Quality items, Section D; Effective Use items, Section E; Individual Impact, Section F; User Satisfaction. A brief description for the variable was added in each section. Questions for sections B,C,D and F uses a scale that range from 1 to 5 which correspond to strongly disagree to strongly agree.

The following table, Table 1 includes items for the study questionnaire draft with source for each construct.

**Table 1 -** Questionnaire Item Draft

| Construct | Items | Questionnaire items | Source |
|---|---|---|---|
| System Quality | 1. Ease of use<br>2. Flexibility<br>3. System integration<br>4. Convenience<br>5. Response and turnaround time<br>6. Ability to recover from errors | 1.The system is easy to use.<br>2.The system is flexible to change in response to new demands.<br>3.The system is able to communicate / exchange data between other systems in different functional areas<br>4.The system is convenience to use.<br>5.The response and turnaround time of the system is acceptable.<br>6.The system is fast to recover from errors. | (Iivari 2005) (Ojo 2017) (McLean and DeLone 1992); Tilahun B, Fritz F 2015) |
| Information Quality | 1. Precision<br>2. Completeness<br>3. accuracy & reliability<br>4. consistency<br>5. relevance & usefulness<br>6. Timeliness | 1.The information provided by the system is precise.<br>2.The information provided by the system is complete.<br>3.The information provided is accurate and reliable.<br>4.The information provided is consistent.<br>5.The information provided is relevant and useful for my work.<br>6.The information provided is timely. | (Iivari 2005) (Ojo 2017) (McLean and DeLone 1992) |

Table 1 (Continued)

| Construct | Items | Questionnaire items | Source |
|---|---|---|---|
| Effective Use | 1. Ability to accomplish tasks without medical errors<br>2. Ability to reach the right medical decisions<br>3. Using the system enables physicians to approach the right medical diagnosis<br>4. Ability to avoid repetition of unnecessary medical tests | 7.Using the system enable me to complete my tasks without committing medical errors.<br>8.Using the system enables me to provide the right medical decision. (self-constructed)<br>9.Using the system enable physicians to approach the right medical diagnosis. (self-constructed)<br>10. Using the system enables clinicians to avoid unnecessary repetition of medical tests. (self-constructed) | DeLone & McLean (1992)<br>(ISO 9241-11:2018(en), Ergonomics of human-system interaction — Part 11) |
| Individual Impact | 1. Accomplish task more quickly<br>2. Make the job easier<br>3. Job performance<br>4. Ability to make medical decisions<br>5. Increased productivity<br>6. Effectiveness at work<br>7. Adherence to best practice guidelines | 1.Using the system in my job enables me to accomplish tasks quickly.<br>2.Using the system makes it easier to do my job.<br>3.Using the system improves my job performance.<br>4.Using the system increased my ability to make medical decision.<br>5.Using the system in my job increases my productivity.<br>6.Using the system enhances my effectiveness in my work.<br>7.Using the system enhances my adherence to Best Practice Guidelines. | DeLone & McLean (1992)<br>Gable, Sedera, & Chan (2008) (Davis 1989) |
| User Satisfaction | 1. Satisfaction with Accuracy of the system<br>2. Friendly use<br>3. Information is sufficient<br>4. Overall satisfaction | 1.I am satisfied with the accuracy of the system<br>2.The system is user friendly.<br>3.The system provides sufficient information.<br>4.Overall, I am satisfied with the system. | (Chin, Diehl, and Norman 1988) (Doll 1988) |

## 7. Pilot Study

The instrument was piloted for 50 applicants including physicians, nurses, pharmacists, laboratory technicians and radiology specialist / technician.

### 7.1 Exploratory Factor analysis (EFA) for Pilot study

The proposed survey instrument with modified question items should be assessed for construct validity and consistency in measuring constructs before being applied to different research and settings(66).

EFA analysis is usually conducted to identify variables which are consistently moving together. It can be defined as is a statistical procedure used to reduce a large number of observed variables to a small number of "factors/components", reflecting that the clusters of variables are in common(66). This analysis captures the groups of observed variables which are consistently moving together. Therefore, EFA is a useful tool for investigating the relations among observed variables and a small number of underlying factors. EFA Analysis was performed for the pilot study.

Table 2 shows the summary for Kaiser Meyer Olkin (KMO) measure for independent variable; System quality & information quality and the moderating variable; Effective use & user satisfaction. Results reflects that measure of sampling adequacy are higher than the acceptable limit of 0.5. Sampling is adequate or sufficient if the value of KMO is larger than 0.5(66). Bartlett's test of sphericity also shows that the significant value for measuring constructs is less than 0.05, which shows that the data is fit for further analysis(67).

**Table 2** – Summary of Kaiser-Meyer-Olkin Measure

| | | Independent Variable | Moderating Variables |
|---|---|---|---|
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | | .816 | .755 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 318.875 | 144.768 |
| | Df | 66 | 28 |
| | Sig. | .000 | .000 |

Table 3 shows that System quality item number 1 **(sysqual_1)** should be removed due to low loading. Items with Loadings close to 0 indicate that the item has a weak influence on the variable. In addition, as per the loading score, the Information Quality item number 6 belongs to System Quality construct.

**Table 3** - Rotated Component Matrix for Independent Variables

| **Rotated Component Matrix[a]** | | |
|---|---|---|
| | Component | |
| | 1 | 2 |
| infoqual_3 | .882 | |
| infoqual_4 | .866 | |
| infoqual_2 | .821 | |
| infoqual_1 | .814 | |
| infoqual_5 | .628 | .553 |
| **sysqual_1** | | |
| sysqual_4 | | .777 |
| sysqual_2 | | .758 |
| sysqual_5 | | .692 |
| sysqual_6 | | .646 |
| infoqual_6 | .478 | .636 |
| sysqual_3 | | .608 |
| Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization. | | |
| a. Rotation converged in 3 iterations. | | |

Table 4 shows the loading scores of Rotated Component Matrix For the moderating variable; Effective use & User Satisfaction. Based on the demonstrated results in Table 5 for items loading scores, relocation and transferring of questions under each variable were changed accordingly.

**Table 4 -** Rotated Component Matrix for Moderating Variables

| **Rotated Component Matrix[a]** | | |
|---|---|---|
| | Component | |
| | 1 | 2 |
| effuse_4 | .827 | |
| usersatisfaction_3 | .762 | |
| usersatisfaction_4 | .706 | .443 |
| usersatisfaction_2 | .631 | |
| effuse_1 | .511 | .477 |
| effuse_2 | | .892 |
| usersatisfaction_1 | | .812 |
| effuse_3 | | .620 |
| Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization. | | |
| a. Rotation converged in 3 iterations. | | |

All modifications that were made for variable items based on EFA analysis are tabulated in Table 5. Results of EFA analysis demonstrated that the applicants understood the meanings of every question in the survey which confirm that the reliability, content validity, and construct validity for the questionnaire draft is established. In addition, it reflects the usefulness of pre-testing of survey questionnaire.

**Table 5** - Revised Questionnaire Items based on EFA Analysis

| Study Variable | Original Item | Source | Improved Items / Source |
|---|---|---|---|
| System Quality | 1. The system is easy to use. | (Iivari 2005) (Ojo 2017) (McLean and DeLone 1992); Tilahun B, Fritz F 2015) | Question was removed due to low loading |
| | 2. The system is flexible to change in response to new demands. | | The system is flexible to change in response to new clinical workflows. (Item was rephrased with specific wordings to enhance clarity) |
| | 3. The system is able to communicate / exchange data between other systems in different functional areas | | The system can communicate and exchange data between other systems in different medical specialties. (Item was rephrased with specific wordings to enhance clarity). |
| | 4. The system is convenience to use. | | No changes made |
| | 5. The response and turnaround time of the system is acceptable. | | No changes made |
| | 6. The system is fast to recover from errors. | | No changes made |
| | | | I get the information I need in time. (added item from Information quality variable based on EFA analysis) |
| Information Quality | 1. The information provided by the system is precise. | (Iivari 2005) (Ojo 2017) (McLean and DeLone 1992) | No changes made. |
| | 2. The information provided by the system is complete. | | No changes made |
| | 3. The information provided is accurate and reliable. | | No changes made |
| | 4. The information provided is consistent. | | No changes made |
| | 5. The information provided is relevant and useful for my work. | | The information provided by the system is relevant to my tasks. (Item was rephrased with specific wordings to enhance clarity). |
| | 6. The information provided is timely. | | The information provided by the system is updated. (Item was rephrased with specific wordings to enhance clarity). |

Table 5 – (Continued)

| Study Variable | Original Item | Source | Improved Items |
|---|---|---|---|
| Effective Use | 1. Using the system enable me to complete my tasks without committing medical errors. | DeLone & McLean (1992)<br><br>(ISO 9241-11:2018(en), Ergonomics of human-system interaction — Part 11) | Item was moved to user satisfaction variable based on EFA analysis |
| | 2. Using the system enables me to provide the right medical decision. (self-constructed) | | No changes made. |
| | 3. Using the system enable physicians to approach the right medical diagnosis. (self-constructed) | | Using the system increases the accuracy of patient diagnosis. (Item was rephrased with specific wordings to enhance clarity). |
| | 4. Using the system enables clinicians to avoid unnecessary repetition of medical tests. (self-constructed) | | Item was moved to user satisfaction variable based on EFA analysis |
| | | | Using the system enables physician to prescribe the right medications to the patients. (New item added) |
| Individual Impact | 1. Using the system in my job enables me to accomplish tasks quickly. | DeLone & McLean (1992)<br><br>Gable, Sedera, & Chan (2008) (Davis 1989) | No changes made. |
| | 2. Using the system makes it easier to do my job. | | No changes made. |
| | 3. Using the system improves my job performance. | | No changes made. |
| | 4. Using the system increased my ability to make medical decision. | | Using the system improves my clinical judgment. (Item was rephrased with specific wordings to enhance clarity). |
| | 5. Using the system in my job increases my productivity. | | Using the system in my job increases quality of patient care. (Nguyen, Bellucci, & Nguyen, 2014) |
| | 6. Using the system enhances my effectiveness in my work. | | Using the system enhances my work efficiency. (Viitanen et al., 2011). |

| | | | |
|---|---|---|---|
| | 7. Using the system enhances my adherence to Best Practice Guidelines. (self-constructed) | | No changes made. |
| User Satisfaction | 1. I am satisfied with the accuracy of the system | (Chin, Diehl, and Norman 1988) (Doll 1988) | No changes made |
| | 2. The system is user friendly. | | No changes made |
| | 3. The system provides sufficient information. | | No changes made |
| | 4. Overall, I am satisfied with the system. | | No changes made |
| | | | The system supports the physician to prevent unnecessary medical tests. (moved item from the Effective use variable based on EFA analysis) |
| | | | The system allows me to complete my tasks without medical errors. (moved item from the Effective use variable based on EFA analysis) |
| | | | Using the system enables me to get real time responses. (new item added) |

# 8. Results

Out of 500 paper- based questionnaire distributed, a total of 315 responses were collected. After data cleaning process, A total of 290 usable or completed responses are used for final analysis, (83%) response rate. It should be noted that data gathered from the field survey is used for this analysis and not the pilot study data of 50 responses that was previously used for EFA.

## 8.1 Descriptive Analysis

Descriptive statistics is used to describe a particular group of individuals observed. Descriptive analysis tests provide simple summaries about the sample and the measures. Description of data is needed to determine the normality of the distribution(68).

Demographics characteristics of study applicants is tabulated in Table 6. Applicants included 132 (45%) males and 158 (55%) females. The higher percentage of female respondents considered reasonable since 177 (61%) of the sample were nurses who are mostly females. The following high percentage of applicants were physicians 58 (20%). Majority of the applicants were from a young age group, 133 (46%) were 25-34 and 93 (32%) were 35 -44 years old. Most of the applicants 131(45%) had more than 5 years of experience in using the HIS in the hospital while 126(43%) had 1-5 years of experience in HIS use.

**Table 6 -** Summary of Demographic Characteristics

| | | | | | |
|---|---|---|---|---|---|
| **Profession** | | | | | |
| | | Frequency | Percent | Valid Percent | Cumulative Percent |
| Valid | Physician | 58 | 20.0 | 20.0 | 20.0 |
| | Pharmacist | 18 | 6.2 | 6.2 | 26.2 |
| | Nurse | 177 | 61.0 | 61.0 | 87.2 |
| | Laboratory Technician | 18 | 6.2 | 6.2 | 93.4 |
| | Radiology Specialist | 19 | 6.6 | 6.6 | 100.0 |
| | Total | 290 | 100.0 | 100.0 | |
| **Gender** | | | | | |
| | | Frequency | Percent | Valid Percent | Cumulative Percent |
| Valid | Male | 132 | 45.5 | 45.5 | 45.5 |
| | Female | 158 | 54.5 | 54.5 | 100.0 |
| | Total | 290 | 100.0 | 100.0 | |
| **Age Group** | | | | | |
| | | Frequency | Percent | Valid Percent | Cumulative Percent |
| Valid | 24 and below | 5 | 1.7 | 1.7 | 1.7 |
| | 25-34 | 133 | 45.9 | 45.9 | 47.6 |
| | 35-44 | 93 | 32.1 | 32.1 | 79.7 |
| | 45-54 | 49 | 16.9 | 16.9 | 96.6 |
| | 55 and above | 10 | 3.4 | 3.4 | 100.0 |
| | Total | 290 | 100.0 | 100.0 | |

Table 6 – (Continued)

| HIS Use Experience | | | | | |
|---|---|---|---|---|---|
| | | Frequency | Percent | Valid Percent | Cumulative Percent |
| Valid | Less than 1 year | 33 | 11.4 | 11.4 | 11.4 |
| | 1-5 years | 126 | 43.4 | 43.4 | 54.8 |
| | More than 5 years | 131 | 45.2 | 45.2 | 100.0 |
| | Total | 290 | 100.0 | 100.0 | |
| **Years of Clinical Practice** | | | | | |
| | | Frequency | Percent | Valid Percent | Cumulative Percent |
| Valid | Less than 3 year | 43 | 14.8 | 14.8 | 14.8 |
| | 3-5 years | 51 | 17.6 | 17.6 | 32.4 |
| | 6-9 years | 68 | 23.4 | 23.4 | 55.9 |
| | More than 10 years | 128 | 44.1 | 44.1 | 100.0 |
| | Total | 290 | 100.0 | 100.0 | |

## 8.2 PLS -SEM for Data Analysis

Structural Equation Modelling SEM technique applied in study data analysis should comply and best suit with the study objectives, data characteristics, and model evaluation(69). The use of Covariance-Based Structural Equation Modelling CB-SEM in SPSS for data analysis to predict the effects between variables through multiple regression method requires normality of data assumption acquiring using random sampling(70,71). In this study Partial Least Square Structural Equation Modelling PLS – SEM was selected for data analysis as the appropriate techniques that could handle the complexity of the model and the non-normality of collected data through convenient sampling(72). In addition, the data acquired is larger than recommended sample size of 129 for a hospital to predict the effects of four independent variables on a single dependent variable(70).

The following PLS – SEM statistical techniques were employed in the data analysis for this study:

4. Reflective Measurement Model Analysis
5. Structural Model Analysis
6. Importance Performance Matrix Analysis (IPMA)

## 8.3 Analysis of the Measurement Model

Statistical analysis in this section explains the reliability and validity measures of the constructs in the model and selected items as success elements for HIS adoption. Achieved results should answer the first research question; *What are the factors used to measure the success of HIS system adoption in the health care setting?*

To test the measurement model shown in Figure 2 certain statistical tests are required. According to Henseler et al.(73) and Hair et al.(72), 1) indicator or item reliability (outer loadings), 2) internal consistency reliability (composite reliability; CR), 3) convergent validity (average variance extracted; AVE), and 4) discriminant validity are required to assess and report the outputs from a reflective measurement model. Indicator loadings of 0.70 and greater are acceptable in exploratory research but loadings below 0.70 and above 0.40 can still be tolerated(74). a CR of 0.60 or greater is acceptable in exploratory research, while AVE must be greater than 0.50(75). An AVE of 0.50 or greater indicates that the particular variable explains more than 50% of the variance of its indicators(71). As tabulated in Table 7, all indicator loadings scored greater than the acceptable criterion of 0.70. Similarly, as did the CR and AVE scores for the established and newly designed indicators. confirming the convergent validity of the latent variables and the correlation between them.

**Table 7 -** Convergent Validity Assessment

| Variable | Indicator | Loadings | CR | AVE |
|---|---|---|---|---|
| System Quality | Sysqual_1 | 0.712 | 0.904 | 0.613 |
| | Sysqual_2 | 0.716 | | |
| | Sysqual_3 | 0.849 | | |
| | Sysqual_4 | 0.816 | | |
| | Sysqual_5 | 0.803 | | |
| | Sysqual_6 | 0.792 | | |
| Variable | Indicator | Loadings | CR | AVE |
| **Information Quality** | Infoqual_1 | 0.874 | 0.940 | 0.724 |
| | Infoqual_2 | 0.865 | | |
| | Infoqual_3 | 0.863 | | |
| | Infoqual_4 | 0.851 | | |
| | Infoqual_5 | 0.838 | | |
| | Infoqual_6 | 0.812 | | |
| **Effective Use** | Effuse_1 | 0.837 | 0.884 | 0.718 |
| | Effuse_2 | 0.868 | | |
| | Effuse_3 | 0.837 | | |
| **User Satisfaction** | Usersatisf_1 | 0.735 | 0.939 | 0.687 |
| | Usersatisf_2 | 0.850 | | |
| | Usersatisf_3 | 0.816 | | |
| | Usersatisf_4 | 0.824 | | |
| | Usersatisf_5 | 0.793 | | |
| | Usersatisf_6 | 0.876 | | |
| | Usersatisf_7 | 0.896 | | |
| **Individual Impact** | Indimpact_1 | 0.846 | 0.960 | 0.773 |
| | Indimpact_2 | 0.903 | | |
| | Indimpact_3 | 0.924 | | |
| | Indimpact_4 | 0.824 | | |

Table 7 (Continued)

| | | |
|---|---|---|
| | Indimpact_5 | 0.905 |
| | Indimpact_6 | 0.918 |
| | Indimpact_7 | 0.829 |

Once convergent validity is established, discriminant validity is assessed using the Fornell–Larcker criterion. This criterion specifies that the average variance shared between a construct and its measures should be greater than the variance shared by the construct and any other constructs in the model(76). As shown in Table 8, the AVE score for every measuring latent variable was greater than its squared correlations in both rows and opposing columns. This indicate adequate discriminant validity for all constructs.

**Table 8** - Discriminant Validity in Fornell-Larcker Criterion

| Variable | Effective Use | Individual Impact | Information Quality | System Quality | User Satisfaction |
|---|---|---|---|---|---|
| **Effective Use** | **0.847** | | | | |
| **Individual Impact** | 0.696 | **0.879** | | | |
| **Information Quality** | 0.686 | 0.634 | **0.851** | | |
| **System Quality** | 0.621 | 0.720 | 0.679 | **0.783** | |
| **User Satisfaction** | 0.716 | 0.849 | 0.730 | 0.811 | **0.829** |

*Note: AVE scores are on the bolded diagonal.*

The same criterion applies with cross loadings. For instance, each effective use indicator loads higher than cross loadings among variable indicators (Individual Impact, Information Quality, System Quality, and User Satisfaction) in Table 9; thus, demonstrating a valid and reliable measurement model.

**Table 9 -** Discriminant Validity in Cross Loadings

| Variable/ Item | Effective Use | Individual Impact | Information Quality | System Quality | User Satisfaction |
|---|---|---|---|---|---|
| **Effuse_1** | 0.837 | 0.541 | 0.533 | 0.488 | 0.566 |
| **Effuse_2** | 0.868 | 0.620 | 0.650 | 0.532 | 0.633 |
| **Effuse_3** | 0.837 | 0.605 | 0.556 | 0.556 | 0.620 |
| **Indimpact_1** | 0.571 | 0.846 | 0.475 | 0.640 | 0.717 |
| **Indimpact_2** | 0.568 | 0.903 | 0.533 | 0.633 | 0.756 |
| **Indimpact_3** | **0.606** | **0.924** | **0.582** | **0.634** | **0.766** |
| **Indimpact_4** | 0.732 | 0.824 | 0.607 | 0.617 | 0.757 |
| **Indimpact_5** | 0.585 | 0.905 | 0.519 | 0.626 | 0.733 |
| **Indimpact_6** | 0.629 | 0.918 | 0.574 | 0.651 | 0.769 |
| **Indimpact_7** | 0.583 | 0.829 | 0.604 | 0.629 | 0.721 |
| **Infoqual_1** | 0.602 | 0.558 | 0.874 | 0.644 | 0.669 |
| **Infoqual_2** | 0.582 | 0.570 | 0.865 | 0.598 | 0.657 |
| **Infoqual_3** | 0.544 | 0.480 | 0.863 | 0.548 | 0.605 |
| **Infoqual_4** | 0.580 | 0.541 | 0.851 | 0.546 | 0.596 |
| **Infoqual_5** | 0.626 | 0.587 | 0.838 | 0.592 | 0.607 |
| **Infoqual_6** | 0.566 | 0.493 | 0.812 | 0.527 | 0.587 |
| **Usersatisf_1** | 0.530 | 0.684 | 0.468 | 0.653 | 0.735 |
| **Usersatisf_2** | 0.564 | 0.729 | 0.566 | 0.693 | 0.850 |
| **Usersatisf_3** | 0.659 | 0.668 | 0.713 | 0.651 | 0.816 |
| **Usersatisf_4** | 0.649 | 0.692 | 0.586 | 0.611 | 0.824 |
| **Usersatisf_5** | 0.587 | 0.664 | 0.568 | 0.648 | 0.793 |
| **Usersatisf_6** | 0.572 | 0.688 | 0.678 | 0.687 | 0.876 |
| **Usersatisf_7** | 0.596 | 0.792 | 0.644 | 0.754 | 0.896 |
| **sysqual_1** | 0.457 | 0.479 | 0.428 | 0.712 | 0.555 |
| **sysqual_2** | 0.480 | 0.550 | 0.514 | 0.716 | 0.539 |

Table 9 (Continued)

| | | | | | |
|---|---|---|---|---|---|
| **sysqual_3** | 0.516 | 0.620 | 0.563 | 0.849 | 0.724 |
| **sysqual_4** | 0.450 | 0.567 | 0.480 | 0.816 | 0.654 |
| **sysqual_5** | 0.479 | 0.576 | 0.535 | 0.803 | 0.661 |
| **sysqual_6** | 0.533 | 0.581 | 0.653 | 0.792 | 0.658 |

## 8.4 Analysis of the Structural Model

Statistical tests for the analysis of structural model were employed to investigate the predictive power of the model and the relationship between its constructs. Results in this section will be answering the second and third research questions; *To what extent do system quality and information quality influence the effective use of HIS and user satisfaction? To what extent do effective use and user satisfaction influence the performance of health care providers?*

To evaluate the structural model, we used the bootstrapping feature (500 resamples) to identify the level of significance for path coefficients n the structural model as proposed by Chin(77) and Gil-Garcia(78). To assess the predictive power *($R^2$)* of the dependent variable, individual impact provided a large $R^2$ score of 0.737 as shown in Figure 3(69), indicating that 74% of this construct was explained by the independent variables. The remaining 26%, however, might be described by other potential constructs not covered in this study.

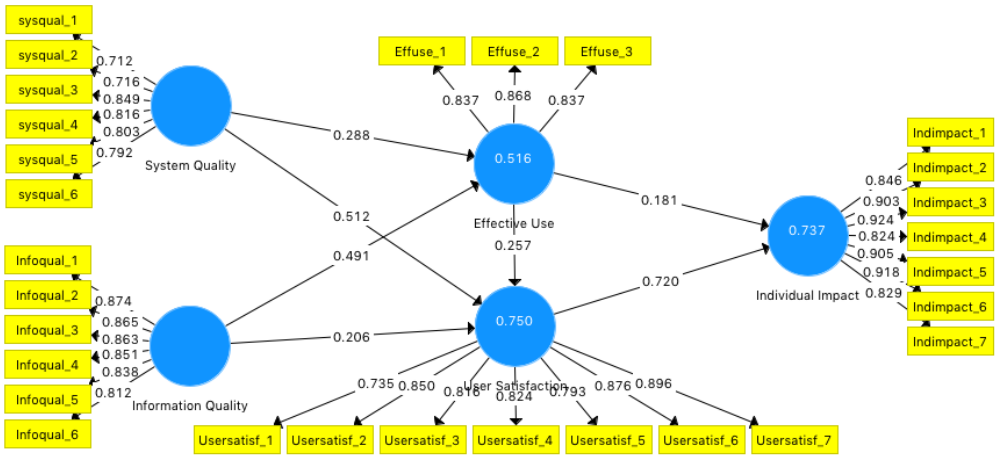


**Figure 3:** Path Coefficients and Predictive Power

In PLS-SEM, there are the three critical values universally considered when conducting the two-tailed tests such as 1.65 with significance level at 10%, 1.96 with significance level at 5%, and 2.57 with significance level at 1% (69). As shown in Figure 4, the results of the *t*-values were calculated for every path, indicating that all paths measured in the model were statistically positive and significant ($r > 1.96$).

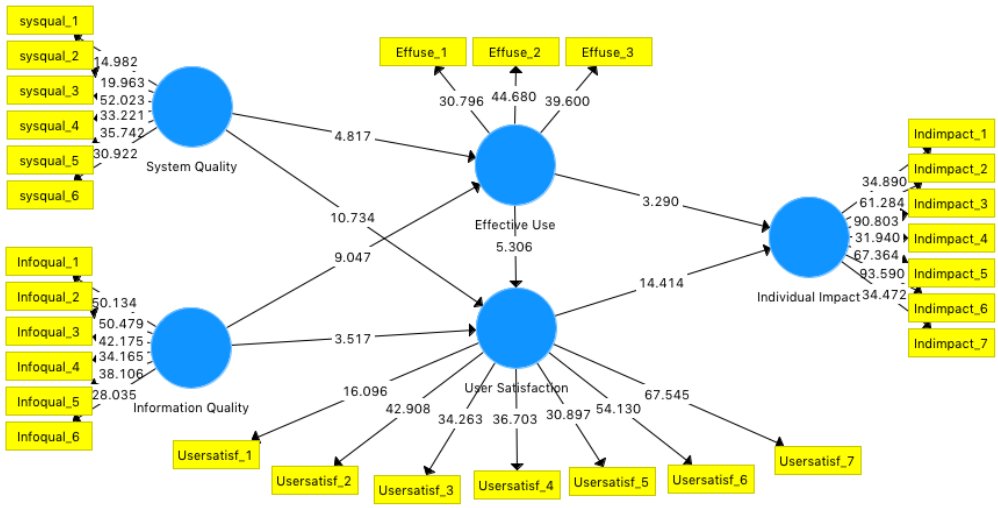


**Figure 4**: Outputs of the Structural Model

The results presented in Table 10 shows that all tested hypotheses were positive and statistically

significant at the 1% level and no construct should be dropped from the model. It was found that information quality had positive effect on user satisfaction with a β value of 0.206 and a t-value of 3.517. While system quality is a strong predictor of user satisfaction with significant positive effect; β value of 0.512 and a t-value of 10.734. In addition, information quality had positive effect on effective use higher than system quality with a β value of 0.491 and t-value 9.047 which make information quality is an almost significant predictor of effective use. Results shows that user satisfaction had the highest positive effect on individual impact with a β value of 0.720 and a t-value of 14.414 in comparison of the effective use. That described the user satisfaction as a strong predictor of individual impact.

**Table 10** - Results for Hypotheses Testing

| Hypothesis | Relationship | Beta (*β*) | Standard Error | *t*-Value | Decision |
|---|---|---|---|---|---|
| H1 | **System Quality -> Effective Use** | 0.288 | 0.060 | 4.817** | Supported |
| H2 | **System Quality -> User Satisfaction** | 0.512 | 0.048 | 10.734** | Supported |
| H3 | **Information Quality -> Effective Use** | 0.491 | 0.054 | 9.047** | Supported |
| H4 | **Information Quality -> User Satisfaction** | 0.206 | 0.059 | 3.517** | Supported |
| H5 | **Effective Use -> User Satisfaction** | 0.257 | 0.049 | 5.306** | Supported |
| H6 | **Effective Use -> Individual Impact** | 0.181 | 0.055 | 3.290** | Supported |
| H7 | **User Satisfaction -> Individual Impact** | 0.720 | 0.050 | 14.414** | Supported |

Note: *$p < 0.05$, **$p < 0.01$ level of significance

## 8.5 Importance - Performance Matrix Analysis (IPMA)

IPMA analysis was conducted to compare perceived HIS influence on the performance of different healthcare professionals under their areas of practice in the hospital. Indented results from this section should be answering the fourth and last research question; *How does the*

*performance of different healthcare providers are compared in terms of effective use and their satisfaction?*

An IPMA continued to compare the performance of the five different care providers by measuring the influence of Effective Use and User Satisfaction on the target variable, Individual Impact. The highest performance score is shaded gray in Table 11. The results indicated that Radiology specialist/technicians scored the highest performance (70%) on effective use of HIS, followed by Pharmacist (69%), and Physician (68%). This meant that the Radiology specialists/technicians are the most effective users of HIS with the strongest performance.

**Table 11** - Performance of Different Health Care Providers

| Target Variable: Individual Impact | Performance | | | | |
|---|---|---|---|---|---|
| | **Physician** | **Pharmacist** | **Nurses** | **Laboratory Technician** | **Radiology Specialist/technician** |
| **Effective Use** | 67.73 | 68.85 | 62.93 | 60.84 | **70.01** |
| **User Satisfaction** | 65.61 | 63.80 | 56.26 | 54.66 | 65.02 |

## 9. Discussion

The key contribution of this research is to investigate healthcare providers perception on the four quality factors of HIS systems toward their performance. In addition of exploring the dimensionality of HIS success measurements using the DeLone and McLean IS success model. The Significant findings of the study have confirmed that the proposed constructs; system quality, information quality, user satisfaction and effective use are the significant predictors for Individual impact. Seven study hypotheses were supported which showed a positive relationship between independent variables (system quality and information quality), moderating variables (effective use and user satisfaction), and dependent variable (individual impact represented as Healthcare provider performance). System quality was found to have the

highest positive effect on user satisfaction. And user satisfaction had the highest positive effect on healthcare providers performance which is represented as individual impact construct. Additional result was achieved by this study indicating that radiology specialists/technicians had the highest performance on effective use of HIS which mean that they are the most effective user of HIS with the strongest performance.

Achieved results have established the validity and reliability of the research model as an evaluation framework for HIS success in hospital context. Investigated system dimensions in this study were proven to be a valid criterion for HIS adoption evaluation that must be considered by hospital administrates when measuring the effectiveness of hospital HIS. This outcome is supported by similar results of previous studies on the reasonableness of using DeLone and McLean IS success model as a predictive model(65,79).

In the model the path from system quality to user satisfaction was found positively significant as hypothesized by DeLone and McLean model. System quality characteristics include ease of use, fixability, exchanging data with other systems, convenience with workflow, response time and error recovery. This is implying that for healthcare professionals, an improved quality characteristic of the system will positively influence their satisfaction, and this will eventually lead to achieve their full potential of HIS performance. This result is in agreement with previous studies on the association between system quality characteristics and user satisfaction(80,81). In a similar study that was conducted at four hospitals in Riyadh, Saudi Arabia for HIS evaluation were system quality included as independent variable(82), it was found that user satisfaction were highly influenced by system quality construct which comes in agreement with present study results. In a another study that elaborated on perceived attributes of computer technology towards its adoption acceptance in Saudi Arabia(83), system complexity was hypothesized to be negatively correlated with user satisfaction. present study findings fully support this hypothesis as system quality characteristics, ease of use, was found to have high

positive effect on user satisfaction. Finally, as reflected in this study result, the power of system quality as predictor of user satisfaction allow us to consider it an effective criterion to analyse system features that may positively influence user satisfaction.

The relationship between user satisfaction and individual impact was assessed. It was found that user satisfaction is the strongest predictor of healthcare providers performance. This result is consistence to previous studies conducted in similar contexts (57,65,81,84). In an assessment study for HIS acceptance in Saudi Arabia hospitals(85), it was found that better satisfaction levels have been associated with positive attitude towards usage and acceptance of system which support findings of present study. User satisfaction is a widespread variable that was proven to be used in measurement of HIS success(86,87). Although some studies have doubted the reliability and appropriateness of user satisfaction as HIS evaluation element considering it as a subjective indicator that is measured based on users' perception(81,88). Assuming that user satisfaction is the user's best estimate of the match between system capabilities and work requirements, a strong relationship between user satisfaction and performance is quite understandable. In addition, study findings suggest that user satisfaction may explain individual impact which was contradicted by Seddon(89) who have claimed that it is people's observations of the outcomes of use, the impacts, that determine their satisfaction with the system, not vice versa.

In a comparison of perceived system influence on effective use among different specialities of healthcare providers, radiology specialists/technicians were found to be the most effective user of HIS with the strongest performance. This could be justified by the advanced technology systems available in Radiology department such as Picture Archiving and Communication System (PACS), voice-recognition dictation system and radiology information system (RIS) that are fully integrated with hospital HIS. Moreover, this result was interpreted by the Radiology department Head upon interviewing as an outcome of the well-established system

process that was structured in an alignment with workflow of radiologists and based on an international standard related to Radiology processes. Alignment of system process with workflow is a system quality characteristic so this result provides an additional agreement that system quality has positive influence on user satisfaction. Moreover, in a study conducted at government hospitals at Eastern province in Saudi Arabia to identify barriers of HIS adoption(90), the lack of customizability of the system per user's workflow was one of the identified common factors for underutilization of the system. This point supports the findings in present study about radiology specialists since one of the main reasons for their high effective use of HIS was the alignment of system processes with their workflow as highlighted by the Radiology Department Head.

Finally, Additional reflections of the results with similar studies in Saudi Arabia contexts were found challenging because of the few numbers of studies found by the researcher about applications of DeLone and McLean success model to evaluate HIS in Saudi Arabia hospitals. Mostly the model was adopted in other eHealth assessment contexts with different applications. Such as assessment for web portals and health mobile Applications in addition of eLearning, Banking and Finance systems assessments.

Despite the significant results found in this study that confirmed the validity of the research model, further studies are required to maintain module credibility, reliability and validity across different disciplines. Considering the significant explanatory power of the model, this research has an added knowledge and meaningful productive implications for performance improvement strategies in healthcare organizations.

## 10. Implications

The HIS evaluation literature was expanded through this research within the individual context in Saudi Arabi which considered an important implication for the theory. In addition, findings

of the study will help the hospitals to improve their system to achieve enhanced performance considering the essential need for Health Information system evaluation. Knowledge gained by this research will support decision makers in healthcare organizations to establish effective evaluations frameworks for their health information systems to asses effectiveness. In addition, this study implies that for healthcare organizations, to improve the user satisfaction of healthcare providers, system quality measures such as ease of use, flexibility and convenience of use must be given the utmost attention. This implication is important considering that user satisfaction was found to have the highest positive influence on healthcare provider performance. Moreover, this research is considered useful for the Information and Communication Technology department in hospitals for their user satisfaction measures through providing insights for defined aspects of improvements in the system features and user interface. Information technology vendors and developer may benefit from this research by focusing on the four highlighted dimensions of the system while developing system functions that contribute to good technical capabilities in HIS.

## 11. Limitation

Study was conducted using cross-sectional study design over three months period which may limit the findings of the respondents' perceptions at that particular time point. In addition, data was collected through self-questionnaire survey which may cause the lack of in depth clarification from respondent's prospective on how the quality characteristics of HIS may contribute to the user outcome considering different clinical specialties. Finally, due to the heavy schedule and complicated nature of practice of healthcare providers, the convenience sampling was employed for data collection in this study and this type of non-probability sample may limit the generalizability of the results beyond other populations.

## 12. Conclusion and Recommendation

larger samples from clinical and non-clinical personnel and random sampling technique is recommended for similar studies for the generalizability of the results from the entire population. Technology and digitalization became a core factor in upgrading the Saudi Arabia healthcare sector, it is recommended for a comprehensive Electronic Health Record evaluation for public & private health care sectors through a longitudinal study using DeLone and McLean IS success model as an evaluation framework. Finally, as user satisfaction is highly impacted the performance of healthcare providers, it is recommended that for further updates or customizations on HIS engagement of clinicians who use the system is essential to promote high user satisfaction. In addition, radiologist can be invited to share their valuable experience in using HIS among other clinicians in clinical seminars/workshops.

## 13. Acknowledgment

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## 15. Appendix I

# Questionnaire / Research study of Evaluating the Hospital Information System Success in Riyadh Tertiary Hospital

Dear participant
I am pleased to present this questionnaire to you. It is a complementary research study to obtain Master Degree in Health Informatics - Public Health at King Saud University.

The main objectives of this study is to evaluate the success factors of the Health Information System (HIS) in addition of assessing the influence of the system on the performance of multiple specialties of healthcare providers.

Kindly note that by answering the following questions you agree to participate in this study knowing that all responses provided will be kept strictly confidential.Based on that you are kindly requested to answer all questions sincerely and to the best of your knowledge.

Instructions : for the statements listed in section B to Section F, Please indicate the extent to which you agree or disagree by marking (✓) against the appropriate scale shown.

NOTE: If you selected the answer "Neutral" it means that you are slightly agree or disagree.

Thank you for your valuable time and participation in this study.
* Required

### SECTION A. DEMOGRAPHIC INFORMATION

Please answer all questions by ticking (✓) one answer only.

1. Your field of practice. *

*Mark only one oval.*

- ◯ Physician
- ◯ Pharmacist
- ◯ Nurse
- ◯ Laboratorist / laboratory Technician
- ◯ Radiology specialist / technician
- ◯ Others

2. Your Gender. *

*Mark only one oval.*

- ◯ Male
- ◯ Female

3. Your Age group. *

*Mark only one oval.*

- ◯ 24 and below
- ◯ 25-34
- ◯ 35-44
- ◯ 45-54
- ◯ 55 and above

4. How long have you been using the Health Information System (HIS) at your current work hospital? *

*Mark only one oval.*

- ◯ Less than 1 year
- ◯ 1-5 years
- ◯ More than 5 years

5. Years of clinical practice *

*Mark only one oval.*

- ◯ Less than 3 year
- ◯ 3-5 years
- ◯ 6-9 years
- ◯ More than 10 years

## SECTION B -SYSTEM QUALITY

System Quality reflects the measures of the Health Information System performance characteristics.

6. The system is flexible to change in response to new clinical workflows. *

*Mark only one oval per row.*

| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|---|
| - | ◯ | ◯ | ◯ | ◯ | ◯ |

7. The system can communicate and exchange data between other systems in different medical specialties. *

*Mark only one oval per row.*

| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|---|
| - | ◯ | ◯ | ◯ | ◯ | ◯ |

8. The system is convenient to use. *

*Mark only one oval per row.*

| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|---|
| - | ◯ | ◯ | ◯ | ◯ | ◯ |

9. The response and turnaround time of the system is acceptable. *

*Mark only one oval per row.*

| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|---|
| - | ◯ | ◯ | ◯ | ◯ | ◯ |

10. The system is fast to recover from errors. *

*Mark only one oval per row.*

| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|---|
| - | ◯ | ◯ | ◯ | ◯ | ◯ |

11. I get the information I need in time. *

*Mark only one oval per row.*

| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|---|
| - | ◯ | ◯ | ◯ | ◯ | ◯ |

## SECTION C - INFORMATION QUALITY

Information Quality measures the characteristics of produced information by the system.

12. The information provided by the system is precise. *

*Mark only one oval per row.*

| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|---|
| - | ◯ | ◯ | ◯ | ◯ | ◯ |

13. The information provided by the system is complete. *

*Mark only one oval per row.*

| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|---|
| - | ◯ | ◯ | ◯ | ◯ | ◯ |

14. The information provided by the system is accurate and reliable. *

*Mark only one oval per row.*

| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|---|
| - | ◯ | ◯ | ◯ | ◯ | ◯ |

15. The information provided by the system is consistent. *

*Mark only one oval per row.*

| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|---|
| - | ◯ | ◯ | ◯ | ◯ | ◯ |

16. The information provided by the system is relevant to my tasks. *

*Mark only one oval per row.*

| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|---|
| - | ◯ | ◯ | ◯ | ◯ | ◯ |

17. The information provided by the system is updated. *

*Mark only one oval per row.*

| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|---|
| - | ◯ | ◯ | ◯ | ◯ | ◯ |

## SECTION D - EFFECTIVE USE

Effective use reflects the achievements of accomplishing clinical tasks by clinicians without significant medical errors.

18. Using the system enables me to make the right medical decisions. *

*Mark only one oval per row.*

| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|---|
| - | ◯ | ◯ | ◯ | ◯ | ◯ |

19. Using the system increases the accuracy of patient diagnosis. *

*Mark only one oval per row.*

| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|---|
| - | ◯ | ◯ | ◯ | ◯ | ◯ |

20. Using the system enables physician to prescribe the right medications to the patients. *

*Mark only one oval per row.*

| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|---|
| - | ◯ | ◯ | ◯ | ◯ | ◯ |

## SECTION E - INDIVIDUAL IMPACT

Individual Impact can be defined as an indication that the Health Information System has produced changes in the user practice and performance.

21. Using the system in my job enables me to accomplish tasks quickly. *

*Mark only one oval per row.*

| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|---|
| - | ◯ | ◯ | ◯ | ◯ | ◯ |

22. Using the system makes it easier to do my job. *

*Mark only one oval per row.*

| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|---|
| - | ◯ | ◯ | ◯ | ◯ | ◯ |

23. Using the system improves my job performance. *

*Mark only one oval per row.*

| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|---|
| - | ◯ | ◯ | ◯ | ◯ | ◯ |

24. Using the system improves my clinical judgment. *

*Mark only one oval per row.*

| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|---|
| - | ◯ | ◯ | ◯ | ◯ | ◯ |

25. Using the system in my job increases quality of patient care *

*Mark only one oval per row.*

| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|---|
| - | ◯ | ◯ | ◯ | ◯ | ◯ |

26. Using the system enhances my work efficiency *

*Mark only one oval per row.*

| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|---|
| - | ◯ | ◯ | ◯ | ◯ | ◯ |

27. Using the system enhances my adherence to Best Practice Guidelines. *

*Mark only one oval per row.*

| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|---|
| - | ◯ | ◯ | ◯ | ◯ | ◯ |

## SECTION F - USER SATISFACTION

User Satisfaction reflects the overall satisfaction of the users during the interaction with the Health Information System.

28. Using the system enables me to get real time responses. *

*Mark only one oval per row.*

| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|---|
| - | ◯ | ◯ | ◯ | ◯ | ◯ |

29. The system is user friendly. *

*Mark only one oval per row.*

| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|---|
| - | ◯ | ◯ | ◯ | ◯ | ◯ |

30. The system provides sufficient information. *

*Mark only one oval per row.*

| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|---|
| - | ◯ | ◯ | ◯ | ◯ | ◯ |

31. The system allows me to complete my tasks without medical errors. *

*Mark only one oval per row.*

| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|---|
| - | ◯ | ◯ | ◯ | ◯ | ◯ |

32. The system supports the physician to prevent unnecessary medical tests. *

*Mark only one oval per row.*

| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|---|
| - | ◯ | ◯ | ◯ | ◯ | ◯ |

33. I am satisfied with the accuracy of the system. *

*Mark only one oval per row.*

| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|---|
| - | ◯ | ◯ | ◯ | ◯ | ◯ |

34. Overall, I am satisfied with the system. *

*Mark only one oval per row.*

| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|---|
| - | ◯ | ◯ | ◯ | ◯ | ◯ |

# 16. Appendix II

مدينة سلطان بن عبد العزيز للخدمات الإنسانية
SULTAN BIN ABDULAZIZ HUMANITARIAN CITY

Date: 09/01/2020
IRB No.: 15-2020-IRB

To: Dr. Samaher Abu Samrah
PI: "Evaluating the Hospital Information System Success in Riyadh Tertiary Hospital"
Sultan Bin Abdulaziz Humanitarian City
E-mail: sabusamrah@sbahc.org.sa

| | |
|---|---|
| Subject: | Approval for Research Project No. 10/SBAHC/RH/2020 |
| Study Title: | "Evaluating the Hospital Information System Success in Riyadh Tertiary Hospital" |
| Study Code: | 11/PhD/2020 |
| Date of Approval: | 08/01/2020 |
| Date of Expiry: | 07/01/2021 |
| Board approval: | All members except the absentees (Dr. Mohammed Khalil, Dr. Enas Shahine, Ms. Samaher AbuSamra, Mr. Mosaab AlManaa) |

Dear Ms. Samaher,

Your Project has been approved and you have the permission to conduct this study following your submitted documents as follow:

1. Curriculum Vitae for the PI researcher
2. Research proposal according to SBAHC IRB Guidelines
3. Letter from the researcher requesting SBAHC participation in the clinical study

You are required to obey by the rules and regulations of the Government of Saudi Arabia, the SBAHC IRB Policies and procedures and the ICH-GCP guidelines. You have to note that this approval mandate responding to IRB's periodic request and surveillance result. Drawing your attention to the following:

- Amendment of the project with the required modification to providing Periodical report for this project specially when study extension is required or expiry before study completion
- All unforeseen events that might affect continued ethical acceptability of the project should be reported to the IRB as soon as possible
- Any serious unexpected adverse events should be reported within 48 hours (2 days)
- Personal identifying data should only be collected when necessary for research.
- Secondary disclosure of personal identifiable data is not allowed.
- Monitoring: projects may be subject to an audit by the IRB at any time.
- The PI is responsible for the storage and retention of original data pertaining to the project for a minimum period of five (5) years.
- Data should be stored securely so that a few authorized users are permitted access to the database.

The IRB registered with the IRB KACST Registration No. H-01-R-090. It is authorized to conduct the ethical review of clinic studies and operates in accordance with ICH-GCP Guidelines and all applicable national/local and institutional regulations and guidelines which govern Good Clinical Practices.

For Future Correspondence, please quote the project number and project title above and you are requested to keep IRB informed about your study progress and submit project progress report every six (6) months. A final report should be provided upon completion of the study.

Wish you a success in your research project.

Yours sincerely,

Prof. Khalid Al-Rubeaan
Chairman-IRB
Sultan Bin Abdulaziz Humanitarian City