

## Evaluation of Healthcare Information System Using Delone and McLean Quality Model, Case study KSA



Muna Elsdag<sup>1,2</sup>, Dua' A. Nassar<sup>1</sup>

<sup>1</sup> Information system Department, Princess Nourah Bint Abdulrahman University, Saudi Arabia, memohamedahmed@pnu.edu.sa, danassar@Pnu.edu.sa

<sup>2</sup>College of Computer Science and Mathematics, University of Bahri, Sudan memahmed@gmail.com

### ABSTRACT

Health information system (HIS) is crucial systems and widely spread and used. Recently, HIS is gaining popularity importance and a boundless potential for developing countries. HIS has adopted by scaled healthcare provider to deliver a qualified patient healthcare services, patient safety, minimum medical faults, efficient and effectiveness patient care and satisfaction by accessing truthful information at anytime and anywhere. In kingdom of Saudi Arabia (KSA), adopted using HIS in many hospitals. This study used Delone & McLean (D&M) quality model to evaluate the quality of these systems to safeguard the quality of patient care. Delone & McLean quality model is the most validated and popular model used to measure the factor of success of HIS system. This research focuses on six interconnected measurements of Information system factor of success criteria that have been provided by the model. These measurements are: information quality, system quality, services quality, user satisfaction, use and net benefits. These factors interrelated and has positively effect to each other. A questionnaire is distributed to all stakeholder of HIS in four hospitals in Riyadh. The questionnaire contains questions measure the six dimensions. The result is collected from the questionnaire and an analysis is conducted to validate the success of HIS and improve the HIS Quality in KSA Hospital.

**Key words :** Information system Quality models, Delone & McLean model, HIS quality.

### 1. INTRODUCTION

Health information systems are essential applications in any health care provider's environment that characterize elementary services for health informatics platform. It provides a service that improves the effectiveness and efficiency of patient health care services by guaranteeing that the information produced and attained is of a high quality. The adoption of Healthcare information system need to be supported by validation the success quality of these systems. To assess and evaluate quality of information system several models are used such as Delone & McLean quality model [1],

Technology Acceptance Model (TAM) Davis's model [2], and ISO Quality model [3]. From these models, Delone & McLean quality model is the most validated and popular model used to measure the factor of success of HIS. This paper focuses on six interrelated dimensions of IS success that have been provided by the model. An analysis will be conducted to improve the HIS Quality in KSA Hospital.

In this paper, the first and second sections are introduction followed by background study. Section three and four expose the research problem, objectives and contributions. In the fifth part, the research quality model "Delone and Mclean(D&M)" is discussed in details with identification of the research hypothesis. Then followed by the study taken through a questionnaire using the quality criteria described in research model. Finally, the results attained are analyzed, discussed and conclusion are deduced.

### 2. BACKGROUND

The measurement of IS success and its effectiveness are critical to recognize of the significance and efficiency of Information System management activities and practices. In 1989, Davis in his doctorate thesis introduced a model to clarify technology user's acceptance behavior that is "Technology acceptance mode" (TAM), which depend on "Theory of Reasoned action" (TRA) and has been implemented successfully by many researcher [2], [4]. The major factors in computer use behaviors that TAM model based on are: observed ease of use factors and observed usefulness factors. Different varieties of information system had implemented Technology acceptance model to analyze the technology use's acceptance behavior. In 1992, D&M model has been developed. They Endeavored to bring consciousness and configuration to the "dependent variable" IS success – in IS research. The D&M IS Success Model was established on empirical and theoretical information system research directed by many of researchers in the period between 1970 - 1980. The D&M model has been validated and implemented in diverse of IS quality assessment and evaluation [1], [5], [6], [18]. Later in 2003, DeLone and McLean reviewed their model. They enhanced trivial adjustments to the model by adding new dimension [5], [7].

In 2012, researchers have introduced an integrated success model [8]. They combined (D&M) updated model and (TAM) model. Subsequently, ten measurements were estimated for quantifying information system success. Finally, ISO models that measure System product and Software quality. ISO quality models is introduced to evaluate characteristics and sub characteristics, for software product, and system product. Both the International Electro technical Commission (IEC) and the International Organization for Standardization (ISO) formulate the particular system standardization over the worldwide, are authority for produce the ISO/IEC205010 quality model [9]. The ISO model is appropriate for both computer systems and software products. ISO/IEC quality model is composed of eight quality characteristics, which are significant to computer systems and all software products. Moreover, these characteristics are reliable terminology for identifying, evaluating and measuring system and software product quality. All characteristics are independent of context and users. The main eight quality characteristics are: functional stability, compatibility, security, efficiency, usability, reliability, portability, performance and maintainability. Different researches used the different model to assess and measure the HIS quality [10], [11], [12], [13], [14], [15], [17]. These characteristics were used in the study. The most popular of these models is the updated Delone and Maclean that adopted to evaluate the factors success of different ISs. In particular, Delone & Maclean model espoused in many HIS studies [18], [19], [11], [14], [15]. They conclude that D&M is a worthy framework, which can be used to evaluate and asses HIS. [18], [19], [11], [14], [15] studies tested the model in developed and developing countries like Ethiopian applied on EMR for Ethiopian hospitals [11].

Cho et al. [14] applied Delone and Maclean Model in three public Korean hospitals to assess and evaluate the performance of new HIS. They find that the quality dimensions are related to net benefit and user satisfaction. [14] Another study done by Petter and Fruhling [15], which used the same model to evaluate medical IS for emergency. They found that service, system and information quality, have an effect on net benefit and user satisfaction [15].

These researches are an evident that Delone and Maclean model strong candidate model to measure and evaluate the success of HIS. This research done using Delone and Maclean updated model to assess and measure the quality of HIS system in Riyadh hospitals' in KSA.

### 3. RESEARCH PROBLEM AND OBJEVTIVES

Health information system has been adopted in many health care providers, however there no evaluation for the success of these HIS systems has been conducted in KSA to measure their quality and assess their success factors. The objectives of this research are:

- i. To measure and evaluate the quality of HIS in Riyadh hospitals
- ii. To assess the success factors of HIS in Riyadh

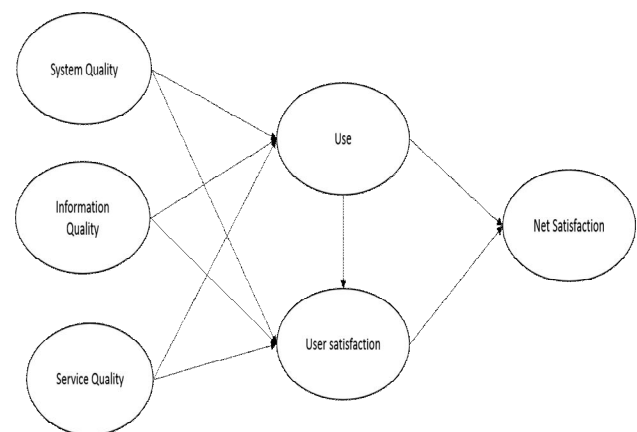
### 4. RESEARCH CONTRIBUTION

Health care system is a vital field and the continuous asses of the service is mandatory to assure the optimal performance. The main contribution we are looking for is to assure the quality of the health care system in Riyadh hospitals, provide the necessary improvements, motivate the usage of HIS in all KSA and suggest resolve any defaults.

### 5. UPDATED DELONE AND MCLEAN QUALITY MODEL

The key guidance of this research is the updated Delone & McLean model [7]. The model bids six correlated conceptions to measure the success of information system, which are: the quality measurements (service, system and information quality) that are shown in Figure1. These six concepts affect the user satisfaction and system use. Moreover, the total of user benefits should be obtained as consequence of the outcome of use and/or user satisfaction. Researchers discuss these model conceptions and their incentive in [10], [1], [12]. This model is explained as follows:

- **System quality** criteria used to measure the attributes of the IS.
- **Service quality** criteria used to measure the term of the quality of provision draw out by information system's inventor.
- **Information quality** criteria used to assess the value of information and the information system characteristics provided by Information System such as: accuracy, reliability, and trustworthiness. This study operationalized information quality in terms of the correctness, usefulness and timeliness of the information generated by the hospital information system in use
- **Intention to use/Use** criteria used to evaluate how IS's stakeholder use the system.
- **User satisfaction** criteria used to evaluate overall user satisfaction. These criteria are the most important.
- **Net benefits** criteria used to evaluate the organization stakeholders net success when using IS in their organization.



**Figure 1:** The criteria and their correlation in Updated Delone and McLean model [5].

### 5.1 Research Hypotheses

According to Delone and Maclean Model a construction and interrelationship between the criteria to be measure are shown in Figure 2. The hypotheses were assumed and were tested are as follows:

- System quality has positive effect to use of HIS (H1).
- System quality has positive effect to HIS user satisfaction (H2).
- Information quality has positive effect to HIS use (H3).
- Information quality has positive effect to HIS user satisfaction (H4).
- Service quality has positive effect to HIS use (H5).
- Service quality has positive effect HIS user satisfaction (H6).
- HIS use will positive effect HIS user satisfaction (H7).
- HIS use has positive effect perceived net benefit (H8).
- HIS user satisfaction will positive effect perceived net benefit (H9).

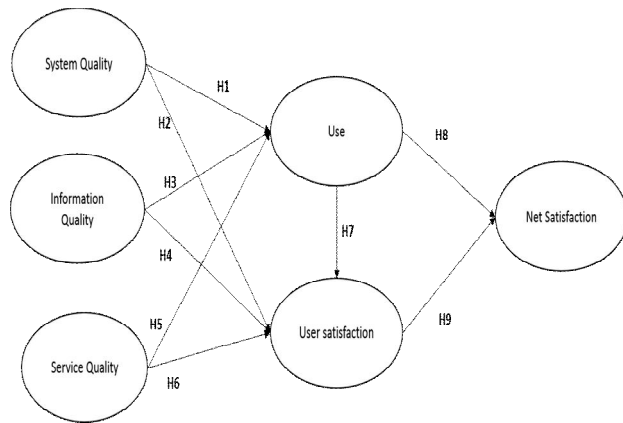


Figure 2: Research Model and hypothesis

### 6. RESULT AND DISCUSSION

For effective and static results, a survey has been conducted and has been distributed to all HIS stakeholders. For this purpose, a questionnaire is distributed (both online and paper-based) in Riyadh hospitals see (APPENDIX A). The total number of response is 210. The main target are Healthcare systems users including doctors, nurses, receptionist, patients and everyone involved in use of the system. The questionnaire cover four hospital in Riyadh. The questionnaire is attached in appendix A. Based on the questionnaire, 24 questions have been divided to six sections established on the sum of the six quality dimensions of IS success measures that we mentioned before. The first one is system quality and it has four questions. The second section is information quality, and it has four questions. The third section is service quality and it has four questions as well, fourth section is Use it contains four questions. The fifth section, which is about user satisfaction, it contains three questions only, and the last section is about net benefit, which contains five questions. A Five Likert scale used. The

respondents were asked whether they strongly agree, Agree, neutral, Disagree and totally disagree with specified questions for each part.

To analyze data and get the result, SPSS used to calculate the regression value, and correlation coefficient. It is used to identify the correlations between the criteria and analyze whether the hypnos H1 to H9 are approved. Moreover, the correlation between criteria are graphical represented.

The regression values for all correlation according to the hypotheses are less than 0.05. These results validate the success of HIS and confirm implementation the success model of Delone & McLean in HIS In Riyadh hospitals.

The second analysis in this study is to calculate the correlation r- value that should range from -1 as a full negative correlation to 1 a full positive correlation. In summary by the following formula:

$$-1 \leq r \leq 1$$

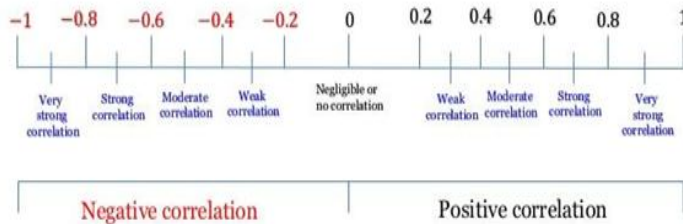
In the correlation r-value; shown in Table 1; if the value is tending to be more than 0.5 indicates positive correlation and proof the success of the correlation between the two criteria.

Table 1: The r- value for H1-H9

Hypotheses	r- value	Result
H1	0.697	Confirm that HIS System quality has a positive effect on use is true
H2	0.752	Confirm that HIS System quality has a positive effect on user satisfaction is true
H3	0.714	Confirm that Information quality has positive effect on HIS use is true
H4	0.737	Confirm that Information quality has positive effect on HIS user satisfactions is true.
H5	0.640	Confirm that services quality has positive effect on HIS use is true
H6	0.682	Confirm that Services quality has positive effect on user satisfactions is true.
H7	0.830	Confirm that Use has positive effect on user satisfaction is true.
H8	0.702	Confirm that Use has positive effect on observed net benefit is true.
H9	0.686	Confirm that User satisfaction has positive effect on observed net benefit is true.

The interpretation of the correlation coefficient is analyzed using the Pearson's correlation coefficient as explained in Figure 3.

This study uses the updated D&M success model in the perspective of HIS used by KSA hospitals. The results obtained show the high quality of health information system in Riyadh hospital since success of the factors according to Delone and Maclean quality model has positive effect.



**Figure 3:** Pearson's correlation coefficient interpretation [16]

The observed relationship strength between dimensions shown significant to other. This result appeared using the regression with 0000 value i.e. for all the correlation coefficients that regressing values are >0.5. This result shows that there is strong relationships between the criteria according to the D&M model hypotheses.

The system quality has positive effect to the user satisfaction and the HIS use. This finding is consistence with results from previous studies. [14], [15], [20] Moreover, information quality positively influence HIS use. This finding is similar to other studies. [11], [14], [15], [20], [21]. In addition, service quality positively affected the HIS use, which appeared in previous studies. [11], [21].

On the other hand, the less correlation factor was the service quality with the use dimension 0.640, which mean need some improvement. This result was same as other studies in HIS, which called for more attention to the service quality to improve user satisfaction. [11], [14], [21]. This consequently has an effect on systems success. While the high positive value is 0.83, which means strong positive effect found among the use and user satisfaction. All correlation coefficient less than 0.7 need to be improved and to pay more attention for them to reach the higher positive effects. Figure 4 shows the graphical representation of the result.

From these results:

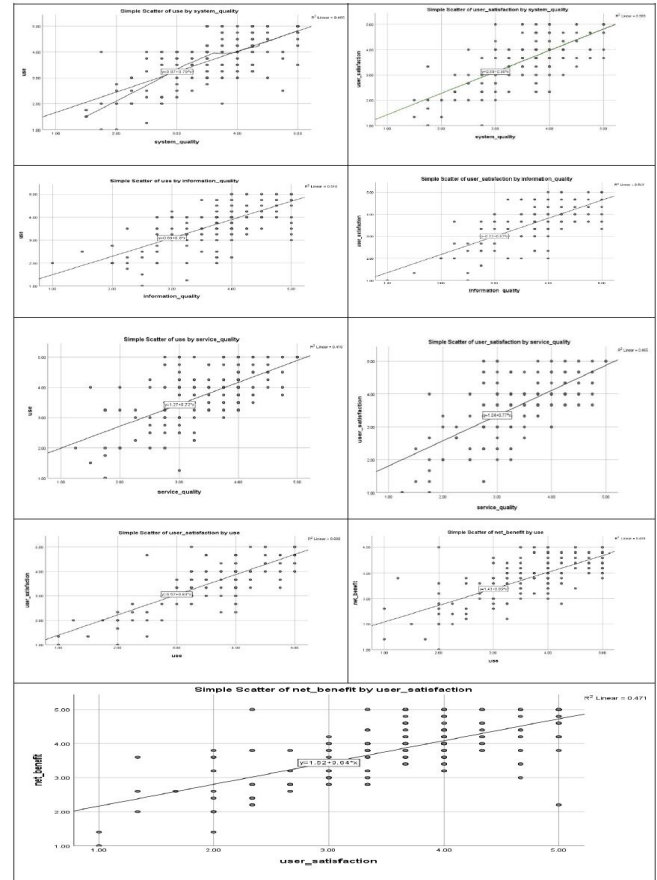
- All the criteria had been evaluated. It showed the evaluation of HIS success factors in four hospitals in Riyadh-KSA.
- The correlation coefficients shows that all correlation between the criteria have positive effect on each other, however, all need to be improved to reach the optimum value, which is 1 particularly, the ones below 0.7. Therefore, to attain success for the HIS, system must be

used, and to use more attention must be paid for service quality.

- The implementation of HIS in Riyadh hospitals validate Delone and Maclean model and is in high quality.

### 5. CONCLUSION

In KSA, HIS provide many services to evolve the usefulness and effectiveness of patient health care delivery. However high patient care reached by ensuring the high quality of generated data and process.



**Figure 4:** The correlation result scatter shows the positive linear correlation for H1 to H9 according to r-value

The adoption of Healthcare information system need to be supported by validation the success quality of these systems. The success quality for KSA HIS were measured by using Delone and Maclean. The case study presented significant results and recommendations. The results show that all six dimension are connected and has a positive effect on each other, mean while many of them need to be evolved for significance success. In the future work, we need to study each criteria individually and its sub criteria to evaluate them specifically for better finding and decision.

## REFERENCES

- [1] WH. DeLone, ER . McLean. **Information systems success: the quest for the dependent variable.** The Insllilulc of Management Stienees, Inf Res; 3(1):60-95., march,1992.
- [2] D. Fred D. **Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology,** *MIS Quarterly* vol 13, pp.319-340. 1989.
- [3] A. Abran, Rafa E. Al-Qutaish. **ISO 9126: Analysis of Quality Models and Measures”, Software Metrics and Software Metrology,** Wiley-IEEE Computer Society, New York, USA, September 2010,ch.10, pp. 205-228,
- [4] V .Viswanath, M. Michael G., G .B. Davis, D. Fred D. **User Acceptance of Information Technology: Toward a Unified View,** *MIS Quarterly,* vol 27, no 3 pp. 425-478, September 2003.
- [5] WH Delone, ER McLean. **The DeLone and McLean model of information systems success: a ten-year update,** *Management Information Systems,* Vol. 19, no. 4, pp. 9–30, Spring 2003
- [6] P. B Seddon. **A Respecification and Extension of the DeLone and McLean Model of IS Success’,** *Information Systems Research,* vol 8, no 3, pp.240-253. September 1997.
- [7] N. Urbach, B .Muller. **Information systems theory: explaining and predicting our digital society,** In: Dwivedi YK, Wade MR, Schneberger SL, New York, Springer, 2012. vol 1,ch 1 pp. 1-18.
- [8] A. H. Zaied. **An Integrated Success Model for Evaluating Information System in Public Sectors,** *Emerging Trends in Computing and Information Sciences,* vol. 3, no. 6, pp.814-825, July 2012.
- [9] ISO/IEC 25010:2011. **Systems and software engineering Systems and software, Quality Requirements and Evaluation (SQuaRE) -- System and software quality models.** [online] Iso.org. Available at: <https://www.iso.org/standard/35733.html>, Accessed 24 Oct. 2018.
- [10]HA .Baraka, IH El-Gamily. **Assessing call centers’ success: a validation of the DeLone and McLean model for information system.** *Egyptian Informatics,* vol 2, no 14, pp.99-108, March 2013.
- [11]B. Tilahun , F. Fritz. **Modeling antecedents of electronic medical record system implementation success in low resource setting hospitals,** *MC Medical Informatics and Decision Making.* Oct 2015, 1186/s12911-015-0192-0.
- [12] AL. Ojo , SO . Popoola. **Some correlates of electronic health information management system success in Nigerian teaching hospitals,** *Biomedical Informatics Insights,* vol 7, no7, pp:1-9, April 2015.
- [13]S. Chatterjee, S. Chakraborty, S. Sarker, FY Lau. **Examining the success factors for mobile work in healthcare: a deductive study,** *Decision Support Syst;* vol 46, no 3 pp620-633, Feb 2009.
- [14]KW . Cho, SK. Bae, JH. Ryu, KN. Kim, CH. An CH, YM. Chae. **Performance evaluation of public hospital information systems by the information system success model,** *Healthc Inform Res,* vol 21, no 1, pp.43–48. Jan 2015.
- [15]S. Petter, A. Fruhling. **Evaluating the success of an emergency response medical information system,** *International journal of medical informatics.* vol7 , no 80, pp.480-489, July.2011.
- [16]H. Akoglu. **User’s guide to correlation coefficients,** *Turkish Journal of Emergency Medicine,* vol. 18, no. 3, pp. 91–93, Agut 2018.
- [17]G. G Gable, D . Sedera , T. Chan. **Re-conceptualizing information system success: The IS-impact measurement model,** *Journal of the Association for Information Systems,* vol 9, no 7, pp.377–408, 2008
- [18]AI. Ojo. **Validation of the DeLone and McLean Information Systems Success Model,** *Healthc Inform Res.* Vol 23, no 1,pp.60-66, Jan 2017.
- [19]C. Bossen, LG . Jensen, FW Udsen. **Review Evaluation of a comprehensive EHR based on the DeLone and McLean model for IS success: approach, results, and success factors.** *Int J Med Inform.* vol 82, no 10, pp.940-953 Oct 2013.
- [20]WY. Jen, CC. Chao. **Measuring mobile patient safety information system success: an empirical study,** *Int J Med Inform,* vol 77, no 10, pp. 689-697, Oct 2008.
- [21]W. Choi, MJ. Rho, J . Park, KJ. Kim, YD . Kwon, IY. Choi. **Information system success model for customer relationship management system in health promotion centers.** *Healthc Inform Res.* Vol 19, no 2, pp.110-120 Jun 2013.

**APPENDIX A**

**QUESTIONNAIRE ABOUT HEALTHCARE INFORMATION SYSTEM (HIS):**

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
I find the HIS easy to use.					
I find it easy to get the HIS do what I want.					
The HIS is flexible to interact with.					
Learning to operate the HIS was easy for me.					
The information generated by the HIS is correct.					
The information generated by the HIS is useful for its purpose.					
The HIS generates information in a timely manner.					
I trust the information output of the HIS.					
There is adequate technical support from the system's provider.					
The overall infrastructure in place is adequate to support the HIS.					
The HIS can be relied on to provide information as when needed.					
The output of the HIS is complete for work processes.					
Using the HIS enables me accomplish tasks more quickly.					
Using the HIS has improved my job performance.					
Using the HIS has made my job easier.					
I find the HIS useful in my job.					
I am satisfied with the functions of the HIS.					
The HIS has eased work processes.					
I am generally satisfied using the HIS.					
The HIS will help overcome the limitations of the paper-based system.					
Using the HIS will cause an improvement in patient care delivery.					
The HIS facilitates easy access to patient's information.					
The HIS will enhance communication among workers.					
HIS use will cause improved decision making.					