An Assessment and Comparison of Information Quality of Hospital Information Systems in Medical-Teaching Hospitals of the City of Isfahan Based on DeLone and McLean's Modified Model

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Abstract: Background: Taking the positive effects of the hospital information systems on patients' treatment process and organization's function into account, it is necessary to evaluate information quality provided by such systems. Hence, the aim of this study was to assess and compare information quality of hospital information systems in medical- teaching hospitals of Isfahan based on the DeLone and McLean's modified Model. **Methodology:** This research was applied and analytical-descriptive in nature and was performed in medical-teaching hospitals of Isfahan in 2010. Research population consisted of hospital information system's users, system developers and IT authorities selected by random sampling method. Data collection instrument was self-designed questionnaire. Questionnaires' reliability was estimated by using Cronbach's Alpha coefficient that was found to be %94.08 and %96.8 for system users' questionnaire and system developers and IT authorities' questionnaire, respectively. **Results:** According to the findings of the study, the difference between the mean scores gained for information quality of all kinds of HISs and different hospitals were statistically significant, i.e. they were not the same ($p<0.05$). Generally, Kowsar system (new version) and *Rahavard Rayaneh* system gained the highest and lowest mean score, respectively. The total mean scores obtained for observing the standards stipulated for information quality was %60.2 for all hospital information systems and %60.8 for different hospitals, respectively. **Conclusion:** According to the results of the research, it can be inferred that based on the applied model, the levelof observing the criteria of hospital information system was rather optimum. Thus, in order to reach a completely optimum condition, it is necessary to pay particular attention to the factors improving information quality, type of activity, type of specialty and property type.

1. Introduction

One of the most significant fields that information technology and information systems are beneficially used is health and care domain. To realize the efficiency, effectiveness and high quality of services and maximize the audiences' level of satisfaction, the use of health information systems (HIS) seems to be an inevitable necessity [1].

Health information system is a composite of data, processes, individuals and information technology mutually interacting with each other for collecting, processing and storing data and providing output required for supporting health and care organization [2].The goal of these systems is ensuring the use of information resources in an appropriate and effective way to promote the performance of health care services [3].

Health information system refers to a collection of data, processes, human beings and information technology which mutually interact to collect, process, store and procure the data required for supporting the medical and healthcare organizations (4) with the aim of ensuring the proper and efficient use of the resources to promote the health care services performance and the society's health.As a part of health information system, hospital information

system satisfies hospitals' needs to the data required for various goals such as operating, planning, patients' care and documentation [5].

Hospital information system includes all-encompassing software that integrates patients' data to make them exchangeable among different sections and medical centers in order to accelerate the patients' care and the treatment process, enhance patients' level of satisfaction, improve the quality of services and finally cut the costs [6]. This system automatically manages the data related to the clinical, financial, nursing, laboratory, pharmacy as well as pathology and radiology departments (7).

Hospital information system is a computerized system developed for satisfying vast information requirements of hospitals and medical centers and also managing the financial issues [8].

Hospital information system is a computerized system which has been designed for the management of all of the medical and administrative-related data of the hospital so that health professionals can perform their duties more efficiently and effectively. This system consists of 8 sub-systems including clinical information system, financial information system, laboratory-related information system, nursing information system, pharmacy information system, picture archiving and communication system and radiology information system [9].

From World Health Organization's point of view, the purpose of designing hospital information system is development of mechanized patient information system all around the world which will lead to the promotion of effective retrieval of the data to be used for medical, statistical, educational and research aims. Hospital information systems are developed for synthesizing and processing data, reporting and using necessary information for improving the efficiency and effectiveness of health services by better management in all levels of health domain [10].

Despite the abundant benefits, these systems have some weaknesses and problems [2] some of which are as follows: expenditures of using such systems are high for the hospitals (especially for the small ones), some organizations do not trust systems' output data [11], the systems have not been designed based on principal and well-known standards [12] and finally the software used is inflexible [13].

Furthermore, the results of evaluative studies carried out on hospital information system reflect the existence of some problems in Iran's hospital information system. For example, one study by Kimiafar (2007) revealed that users are not satisfied with the data quality and capabilities of hospital information system applied in Mashhad medical-

teaching hospitals[14].Various software packages having special informatics formats are not sufficiently available or, if any, the shared use of them is either impossible or very difficult [15].

Hence, identifying and resolving these problems requires continuous evaluations that must be done before, after as well as during the administration of information systems [12]. Continuous evaluation is one of the four main stages in the development of information systems [16].The purpose of this stage is to determine and evaluate the performance of sub-systems of health information system and identify their challenges and difficulties [17].According to Gizzler et al (1998), the aim of evaluation is to determine to what extent the performed actions conform with the standards, to promote the efficiency and effectiveness, to be used as a basis for planning and as a tool for communicating among various activities within the health care and medical information systems[18].

Evaluation is a continuous process which is endless [2]. In information system evaluation, the focus is on the quality [14]. The quality of information depends on some factors such as accuracy, timeliness, completeness, comprehensibility, correctness and etc. [19, 20]. World Health Organization, enumerate correctness, timeliness, completeness, comparability, newness, accuracy and relevance as the information quality characteristics [10].

Different models exist for evaluating the health information system one of which is DeLone and McLean's successful information system model. Conducting a comprehensive and all-encompassing study on the criteria effective in the evaluation of information systems, DeLone and McLean proposed their model which consists of six criteria and is used as a comprehensive model for information systems evaluation. In this model, six main dimensions covering the overall performance of the systems are emphasized [22]. One of these dimensions is information quality. Information quality deals with the quality of information system's output [20]. Information quality characteristics are accuracy, precision, timeliness, completeness and format of the information and reports, perceived usefulness of the specific reported items, perceived importance, comparability, usefulness, relevance, understandability of the information and reports[19, 23].

The goal of information quality assessment is clarifying the information systems' weaknesses and strengths in terms of quality and providing guidance for the improvement of the systems' applications [12]. During recent years, a lot of studies have been done on the importance of evaluating the quality of hospital information systems. The results of these studies have provided some evidence on the inappropriate quality

of systems' information i.e. the existence of some problems as far as quality of hospital information system is concerned [14] .In another study, Honmer (2004) found that there are some problems in the quality of information obtained from the hospital information systems applied in South Africa. These problems have entailed users' relative satisfaction with these systems [24]. Considering the fact that high quality of information is not only critical in their use in patients' caring process but also in the assessment of the performance of the users and health institutes [25] and regarding the old proverb used about computerized systems i.e. "rubbish in, rubbish out", it can be said when information that lack required characteristics enter a system that gradually gets greater, quicker and more complex, more rubbish will certainly be produced and distributed among a wider range of the users[21].Therefore, the present study has been devoted to the assessment and comparison of information quality of hospital information systems in medical- teaching hospitals of Isfahan based on DeLone and McLean's adjusted model.

2. Materials and Methodology

The present research was conducted as an applied research based on descriptive cross-sectional method. Using DeLone and McLean's suggested criteria for evaluating information quality, the researchers tried to evaluate the hospital information systems applied in medical-teaching hospitals situated in city of Isfahan, Iran. The hospitals under study were 11 medical-teaching hospitals which are as follows: Shahid Beheshti, Shahid Chamran, Noor, Ali Asqar, Imam Moosa Kazem, Isa Ibn Maryam, Al-zahra, Ayatollah Kashani, Feiz, Sayyed Al-shohada, Farabi and Amin. All of them were situated in the city of Isfahan. The time of the study was from October to January in 2010. The population under study included hospital information systems' developers, hospital IT authorities and hospital information systems' users working in the hospitals in question.

Due to the small size of the statistical population related to system's developers and hospital IT's authorities, sampling was done by consensus method, therefore the size of the sample is the same as the population. For the hospital information systems users, first of all the total number of users in each hospital was determined. Then, based on the minimum and maximum number of the users, the size of the sample was calculated by the following formula:

$$n_k = \frac{(z_1 + z_2)^2 (2s)^2}{d^2}$$

The estimated size of the sample for each hospital was found to be at least 20. In overall, for all hospitals, 220 people were selected (for the users group, sampling was done by using random sampling method).

The tool used for collecting the data was a self-designed questionnaire developed based on DeLone and McLean's model for information quality criteria. To do so, two questionnaires were separately designed (one for hospital information system's developers and hospital IT authorities and one for hospital information system's users).

As far as the method of collecting data is concerned, it should be said that the researcher went to the hospitals under study in person to distribute the IT authorities' and system users' questionnaires. The hospital information system developers' questionnaire was directly delivered to the target individuals present in the hospitals. Otherwise, the questionnaire along with the necessary explanations was sent to them by electronic e-mail.

The content validity of the questionnaires was confirmed based on views given by faculty professors, computer science experts, hospital information authorities and information management and health informatics personnel in administrative units.

In order to estimate the questionnaires' reliability, Cronbakh Alpha coefficient and SPSS software were applied. The estimated coefficient for hospital information system developers' and hospital IT authorities' questionnaire and system user's questionnaire were 96/8% and 94/08%, respectively.

After collecting the data and their final control, they were put into SPSS 18 software. For analyzing the gathered data using measurement tools and converting qualitative responses to quantitative ones, the item weighing method was used. Furthermore, for the evaluation of the respondents' opinions and the comparison of the mean scores of each criterion, the 5-item Likert scale and one-way variance analysis were used, respectively.

3. Results

The demographic attributes studied in the present study included gender, age, level of education and field of study.

In system users group, the majority (42/5%) aged 20-30, 70/6% were female and the majority of them %49/6 were graduate students (had B.A degree).

In system developers and hospital IT authorities group, the majority of individuals i.e. 53/8% aged 20-30, 63/5% were male and the level of education of most of them (69/2%) was B.A.

Table 1 represents the mean scores of the information quality components for different types of hospital information systems applied in the study population.

It is worth mentioning that number 1 given under the table refers to system users group and number 2 indicates the system developers and hospital IT authorities group.

Table 1: The Mean Scores Obtained for Different Components of Information Quality in Different Hospital Information Systems in Population under Research

Components	Type of HIS											
	Modireyat Amare Daneshgah		*Kowsar* (old version)		Kowsar (modern version)		Sayan Rayan Ekbatan		Rahavard Rayane		Pouya Samaneh Diva	
	1	2	1	2	1	2	1	2	1	2	1	2
Accuracy	60.3	80.5	60	75	56.5	87.4	60.4	78.7	43.3	34.4	47.2	63.6
Precision	61.6	81.2	57.9	56.2	57	75	61.1	80.8	49.6	67.2	51.9	75.6
Timeliness	55.8	87.5	64.6	87.5	62.9	90.1	59.5	90.4	43.7	65.6	50.4	68.2
Completeness	55.4	77.3	51.2	56.2	46.7	50	59.5	56.6	41.2	51.5	44.8	60.8
Format	60.1	86.9	64.5	75	64.5	100	62.3	88	46.7	60	50.7	75
Perceived usefulness specific report items	60	65.6	60.8	50	50.6	95.2	60.4	94.2	47	62.5	49.2	67.4
Perceived importance information item item	64.4	70.8	67.5	75	56.5	100	62.4	90.5	52.5	64.6	62.7	77.2
Comparability	64.4	58.7	61.6	60	50	80	61.3	70	59.1	58.7	49.2	67.4
Usefulness	53.4	72.9	64.4	70.8	58.9	100	58	82.7	44.8	69.8	52.9	60
Relevance	57	56.2	66.9	50	64.8	100	57.8	86.6	46.9	60.4	51.2	67.4
understandability	49.7	-	54.2	-	54.3	-	59.9	-	40.8	-	51.2	-

Table 2 shows the results of the comparison of mean scores of information quality in different hospital information systems used in the population under study. In terms of information quality criteria, based on users' questionnairethe highest and the lowest mean score belonged to *Kowsar* system (old version) (60/8%) and *Rahavard Rayane* system (46/3%), respectively. But based on the results of system developers and IT authorities' questionnaire the highest and lowest mean score related to information quality component belonged to *Kowsar* system (new version) (92/3%) and *Rahavard Rayane* system (59/4%), respectively.

The results of one-way variance analysis indicated that the mean scores of information quality for different hospital information systems were statistically significant. ($p \leq 0/05$).

Table 2: Comparison of Mean scores information quality in different hospital information systems in population under study

population under study \ Type of HIS	developers & IT authorities	systems' users
Kowsar (modern version)	92.3	56
Kowsar (old version)	68.6	60.8
Sayan Rayan Ekbatan Hamedan	82.5	59
Daneshgah Modireyat Amare	76.5	56.9
Rahavard Rayane	59.4	46.3
Poya Samaneh Diva	69.01	50.7

Table 3 represents the results of the comparison of the final score of information quality component for different hospital information systems under study. All in all, *Kowsar* system (modern version) and *RhavardRayaneh* system gained the highest and lowest mean score, respectively.

Table 3: The Comparison of the Final Mean Scores of Information Quality for Different Hospital Information Systems

Type of HIS \ Criteria	information quality
Kowsar (modern version)	63.5
Kowsar (old version)	62.1
Sayan Rayan Ekbatan Hamedan	61.7
Modireyat Amare Daneshgah	61.02
Poya Samaneh Diva	57
Rahavard Rayane	50.04

The results of one-way variance analysis indicated that the difference between the final mean scores of information quality for different hospital information systems were statistically significant. ($p \leq 0/05$).

According to the results of the comparison of information quality mean scores among various hospitals and based on users' questionnaire, Beheshti hospital gained the highest mean (62/5%) and Feiz hospital the lowest mean (46/3%). In terms of system developers and IT authorities' questionnaire, the highest and the lowest mean went to Isa Ibn Maryam (92/9) and Farabi (53/2%) hospitals, respectively.

Table 4: The Comparison of the final Mean Score information quality in significant among different hospitals

Criteria Hospital	information quality
Isa Ibn Maryam	57
Ayatollah Kashani	62.1
Farabi	55.4
Shahid Chamran	67.4
Noor & Ali Asqar	61.3
Al-zahra	63.5
ShahidBeheshti	62.8
Imam MoosaKazem	59.3
Sayyed Al-shohada	63
Amin	56.9
Feiz	50

As it is seen in table 4, in terms of information quality, Chamran hospital acquired the highest mean (67/4%), while Feiz hospital gained the lowest mean (50%). In addition, the results of one way variance analysis indicated that the overall mean scores obtained for the information quality component were statistically significant among different hospitals (p ≤ 0/05).

4. Discussion

With a view to the study results, it can be said that based on system users' questionnaire "perceived importance of each information item" and completeness of information "components acquired the highest and lowest desirability, respectively. Therefore, it can be claimed that the systems under study have some weaknesses and inefficiencies as far as "completeness" as a significant attributes of information quality is concerned.

According to system users' questionnaire, information quality criterion was in a relatively desirable condition in different hospital information systems.

According to the results of system developers and IT authorities' questionnaire, the "timeliness of information and report" component had the highest desirability while "Completeness of information" component had the lowest desirability. As the results show, in developers group the "completeness of information" component has had the lowest desirability too. Hence, it can be inferred that the systems under study experiences serious inefficiencies in terms of this component. Consequently, the developers, managers and users must take serious actions in order to overcome these weaknesses.

Based on system developers and IT authorities' questionnaire results, the criterion of

information quality was in a relatively desirable condition in different hospital information systems.

The systems under study were in a relatively appropriate condition in terms of information quality i.e. they have some weaknesses and deficiencies. Mean score for the overall condition of information quality in the systems was 60/2%. This value was significantly far from the maximum and optimum mean score i.e. 100. In overall, it was in a relatively desirable condition which was far from desirable condition. Hence, the results of the present study were in line with Kimiafar's research entitled *"The Information Quality and Views of Users towards the Quality of Hospital Information System in Teaching Hospitals of Mashhad"*. The results of this study indicated that generally 53/2% of the users were satisfied with the information quality in hospital information systems to some extent [14]. In the present study, the mean score of information quality was also in a desirable condition. Furthermore, Kimiafar's study on the hospital information systems users' views towards the information quality characteristics indicated that 45/6% of the users evaluated the hospital information system as accurate, 48.1% to some extent complete, 39% applicable, 45.5% to some extent adequate, 55.4% comprehensible, 45.6% to some extent secure, 43.6% to some extent timely and 51.9% highly reliable.

The results of the present study were also in line with the study done by Honmer (2004) entitled *"Evaluation of Hospital Information Computerized Systems in South Africa Public Hospitals Based DeLone and McLean's Model"*. Honmer found that there are some deficiencies in the quality of the information obtained from hospital information system used in South Africa which had led to the relative satisfaction of users with these systems [24].

In terms of information quality components in different hospitals, the results of evaluation were the same as the present study. As far as information quality criterion in different hospitals is concerned, among the 11 hospitals under study just 1 hospital had a desirable condition (mean score 64.7 %). Of course all of the hospitals were far from optimum condition and in sum, the mean score related to information quality was in a relatively desirable level (60/8%).

The above results obtained from the evaluation of information quality in different hospitals can be justified in the following way: Certainly the kind of hospital's task (medical, medical-teaching), type of hospital's expertise (general, professional) and the type of hospital's ownership (medical-science university, private sector hospital) may have a direct and significant effect on the quality of hospital information systems. The

mean score of information quality criterion was not the same for all the hospitals under study. This may have resulted from the effect of hospital's task, expertise and ownership type. Hence, in designing hospital information systems special attention should be paid to the foregoing factors especially to the hospital's expertise type.

5. Conclusion

Designing and evaluating hospital information system based on standard and known models seems to be an inevitable necessity for having systems and data of high quality as well as acquiring user's satisfaction. In whole, the present study showed that the six hospital information system in question were significantly different in terms of their information quality. *Kowsar* system (new version) had the highest mean score in this criterion. As far as the comparison of different hospitals is concerned, the highest mean score for this criterion belonged to Chamran hospital. This may be due to the effect of hospital's task type, expertise type and ownership type. In most of the results of the present study *Rahavard Rayaneh* system had the lowest mean score on all criteria under study. Oldness and being under running DOS program can be enumerated as two weaknesses of this system.

Although *Kowsar* system had the highest mean score in terms of information quality criterion, it has also some deficiencies that must be obviated. The results of the present study on the evaluation of systems were different for system's users and system's developers groups which the following reasons can be used for its justification: the difference of users and systems developers' expectations from the system, difference in users and system developers' status, difference in system users and developers' level of education and cognition, and finally system developers' sense of belonging towards the system.

6. Suggestions

1. The high volume of the workload and the shortage of the personnel in medical-teaching hospitals have led to the inaccuracy in entering the data. This, in turn, has resulted in the low quality of information which demands critical measures.
2. Through holding training workshops and delivering training pamphlets by hospital information system's back-up group, we can enhance the quality of information.
3. All data available in the system should be timely. They should become up-to-date by applying UML documentation tool in a mechanized way.

4. The required capabilities for editing data and correcting errors at the time of working with the system should be elevated.
5. When submitting the data to the data center, the accuracy of the data should be checked by the database management system program.
6. The system must be equipped with data dictionary.

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