

Modeling the Determinants of Medical Information Systems Usability in Saudi Arabia

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Abstract—Saudi Arabia’s healthcare sector is rapidly moving towards fully automating medical records in all hospitals throughout the country to create the ability to have the medical information move from hospital to hospital as announced in ambitious e-health program. In spite of the wide adoption of IT systems in healthcare sector, very little limited research has been conducted to investigate health and medical information systems perceived usability within the Saudi context. This paper attempts to fill the gap in the literature of medical information systems usability by modeling the usability determinants of Medical Information Systems within the context of Saudi Arabia.

Keywords-Usability testing; usability measures; medical system

I. INTRODUCTION

The role of Information and Communication Technology (ICT) has shown significant impacts on most aspects of life in Saudi Arabia during the last decades. Both government and private sectors made huge investment in ICT infrastructures and have shown growing trend to adopt ICT as strategic enabler to leverage the efficiency and effectiveness of their processes. Saudi Arabia’s healthcare sector as an important example is rapidly moving towards fully automating medical records in all hospitals throughout the country to create the ability to have the medical information move from hospital to hospital as announced in ambitious e-health program under which about 220 hospitals and 2,000 Primary Healthcare Centers (PHCs) will be automated [1][2]. However, there are still several barriers to successful implementation of medical information systems [3][4].

In spite of the wide adoption of IT systems in healthcare sector in many countries, criteria addressing usability are notably absent [5]. In this regards, the health-care industry faces various challenges and great pressures in order to adopt IT. The successful adoption and utilization can greatly lead to reduce process inefficiencies and health-care cost. In addition, health care quality can be also improved. However, having adopted IT in healthcare industry may lead to error-prone and misuse by users "clinicians" [5]. Thus, testing and evaluating healthcare information systems usability can play a vital role in making such systems and reducing errors.

Usability engineering methods tend to measure systems usability. It aims to shorten lifecycle of systems developments, improve quality of the systems and reduce the cost [6][7][8]. The requirements of a certain system usually depend on its characteristics such as medical systems usually aims to achieve users' trust while working under pressure, accommodate users errors and very reliable, safe and accurate [9]. Failing to achieve the expected requirements can cause severe usability problems. For example, having a default value caused serious issues. This has been reported as a failure to enter a new dosage levels as the system did not prompt the user for the data [9]. Another reported example is that the poor usability is the given reason for having critical errors and may result to lethal implications [6][10]. In fact, significant hazard can be caused by poor usability [9]. Hence, it can be seen clearly the importance of having a usable medical system taking into account usability guidelines. However, in order to measure usability properly, usability measures of medical systems should be clearly identified and properly recorded. An extensive review on existing usability measure and models is presented in [11].

The current literature suggests that a "reasonable" usability is acceptable in medical systems, although others systems aim to achieve high level of usability. This can be seen due to the nature of medical systems. These types of systems prioritize different attribute such as safety, accurately and efficient as critical factors, whereas other types of systems such as e-commerce classify user satisfaction, effectiveness and learnability as critical factors [6][10]. The latest published medical usability standards attempt to control safe use. It has been classified as a critical standard for medical system usability [6][9]. Moreover, efficiency and error free use have been described to be success factor of Electronic Health Records (EHRs). Although, there are some commercial medical systems, they can not tailor all the needed specification of a certain clinic or a hospital [6].

From measurement prospective, measuring medical system is a different from measuring other types of system. The reasons are: Firstly, medical system has a different nature of clinical work domain, such as multiple users sometimes are required to perform a task. Secondly, privacy and legal issues can be a significant obstacle [6]. Usability testing is usually recommended to be conducted naturally. In

addition, poor measurement of system functionality and usability may lead to patient injuries and deaths [9]. Even most skilled users can be misled by user's interfaces if they do not follow specific design guidelines [9]. Furthermore, medical devices and systems have to be used effectively and safely, therefore their interaction and design should be considered when design and evaluate [6]. However, recent researches aim to provide usable health systems to enable their users to concentrate on their patients rather than the systems issues [6]. In addition, it has been reported that each dollar spent on usability can offer up to 30 dollar in systems investment. Usability is now a fundamental criterion to buy software [12].

In this paper, we attempt to fill the gap of the literature of medical information systems usability by proposing a set of customized usability measures for medical information systems in Saudi Arabia. Specifically, the objectives of this research are: to explore the current literature of medical information systems in Saudi Arabia, to propose a set of customized measures on medical information systems in Saudi Arabia, and to empirically examine the current usability issues of medical systems in Saudi Arabia through applying customized measures.

II. LITERATURE REVIEW

Recently, there was a growing literature focus on healthcare information systems usability. Viitanen et al. [13] used a national web questionnaire with nearly 4000 physicians actively working in patient care in Finland. They described three dimensions of clinical ICT system usability: compatibility between clinical systems and physicians' tasks, the support for information sharing and collaboration in clinical work. Their results indicated several usability problems and deficiencies which considerably hindered the efficiency of clinical ICT use and physician's routine work.

Kjeldskov et al. [14] conducted a usability evaluation with novice users when an electronic patient record system was being deployed in a large hospital. They repeated the evaluation After 15 months of system usage by the nurses in their daily work. Results show extensive use and experience with systems will not solve usability problems.

Khajouei et al. [15] examined and compared the effectiveness of Cognitive Walkthrough (CW) and Think Aloud (TA) usability evaluation methods, for identifying usability problems. Their study involved two usability evaluators and 10 physicians were recruited to perform usability testing of a CPOE system (Medicator). Results from this study show that there is no significant difference between the performance of the CW and the TA methods in terms of number of usability problems identified and the mean severity of these problems. They recommended a combination of methods is advised as the most appropriate approach for usability evaluation to avoid problems which can lead to potentially fatal consequences.

Karahoca et al. [16] examined usability of two alternative prototypes for medical information systems using Nielsen's heuristic evaluation and cognitive walkthrough methods. Their study is based on a case study of 32 potential users of

medical information system prototypes. Their case study results confirmed the view that the usability evaluation results of iconic Graphical User Interfaces (GUIs) were better than those of non-iconic GUIs in terms of Nielsen's heuristic evaluation, effectiveness and user satisfaction.

Jaspers [17] presented an overview of the methodological and empirical research available on the three usability inspection and testing methods most often used for testing interactive health technologies: the heuristic evaluation, the cognitive walkthrough, and the think aloud.

Horsky et al. [18] conducted a research study to characterized and compared four usability evaluation methods used during the design and pilot testing of new clinical documentation software. Their results reported that no single evaluation method outperforms others methods in detecting all or most usability problems.

III. RESEARCH METHOD

This research is intended to identify the critical factors or determinants for measuring the perceived usability of Medical/Health Information Systems. By Medical/Health Information Systems we mean all types of computerized information systems developed for recording, processing, retrieving and managing patients' medical/health information. Based on an extensive review of relevant literature, eight usability measures were selected and included in the research investigation. These measures are: Learnability, Safety, Trustfulness, Usefulness, Effectiveness, Efficiency, Satisfaction, and Productivity.

A. Measurement Development

This study is based on the survey questionnaire method for the purpose of collecting the required data. The survey questionnaire tool used consists of three parts: the first part is designed to collect the participants' demographic data, the second part is designed to get the participants' rating of proposed factors, and last part is used to record participants' attitude toward using Medical Information Systems.

The survey questionnaire measurement tool included 34 items forming 8 latent variables. Cronbach's alpha was used for testing the internal consistency reliability of the scale. All constructs reported alpha value above the acceptable threshold of 0.7, except the learnability which reported a value of 0.59 (see table 1) . This construct was removed and excluded from any further analysis. In addition, convergent validity of the constructs was tested using a principal component analysis. Only factors with eigenvalues greater than 1.0 and component loadings exceeding 0.5 were considered significant and hence kept for further analysis.

TABLE 1. RELIABILITY STATISTICS FOR THE CONSTRUCTS

Construct	N of Items	Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items
Learnability	4	0.597	0.569
Safety	5	0.798	0.801
Trustfulness	4	0.811	0.811
Usefulness	4	0.726	0.728
Effectiveness	7	0.840	0.842
Efficiency	3	0.822	0.823
Satisfaction	2	0.670	0.670
Productivity	3	0.748	0.748

B. The Study Sample

A total number of (200) forms were distributed to medical staff working in public and private hospitals in Saudi Arabia. Later, (104) survey questionnaire form were returned making a response rate of (52%). Five forms were excluded from any further analysis because of missing data. Hence, the remaining (99) valid filled survey forms were used in the analysis. The females represented a majority of the respondents (75.8%) indicating low participation from males. The majority of respondents aged between 20 and 40 years (77%). The data indicated that 26.3% of the respondents have no experience with any Medical Information Systems at all. In addition, 23 % reported less than one year experience with Medical Information Systems. While 54% of the respondents reported more than 6 years of experience with using computers, only 16% of the sample reported more than 6 years of experience with using Medical Information Systems (see Table 2).

TABLE 2. DEMOGRAPHIC CHARACTERISTICS OF THE RESPONDENTS

Measure	Item	Frequency	Percentage
Gender	Female	75	75.8%
	Male	24	24.2 %
Age	Between 20-30	49	49.5 %
	Between 31-40	27	27.3 %
	Between 41-50	12	12.1 %
	Over 50	9	9.1 %
	Missing	2	2.0 %
Experience with Computer	Less than a year	8	8.1 %
	1 to 6 years	33	33.3 %
	Greater than 6 years	55	55.6 %
	Missing	3	3.0 %
Experience with any HIS	No experience	26	26.3 %
	Less than a year	23	23.2 %
	1 to 6 years	25	25.3 %
	Greater than 6 years	16	16.2 %
	Missing	9	9.1 %

IV. RESULTS AND ANALYSIS

The analysis of this paper is based on average values of the responses for each factor to identify which factors can be

considered critical for each usability measure. The factors with means exceeding or equal to 4.11 were recognized as critical factors.

Based on this analysis, factors that were identified as critical for health information systems safety are: (1) personal information should be protected, (2) the system should explain the errors clearly, (3) the system should explain what to do when a problem faces users, (4) resources should be handled without any hazard, (5) the system should maintain a specific level of performance in case of being faulty. According to results from Analysis of Variance (ANOVA), there is no significant difference between female ratings for this measure. But, this analysis reports a significant effect of the flow of experience with using computers on the respondents' rating for the fifth item in this measure (p value=0.02).

The factors that were identified critical for health information trustfulness are: (1) visual and text content should be easily understood, (2) the system should give clear user assistance in its operation, (3) the system should be clear in terms of its purpose and objectives, (4) the user should feel in control of the system product. According to results from analysis of variance (ANOVA), there is no significant difference between female ratings for this measure. Also, there is no significant effect of the flow of experience with using computers or HIS on the respondents' rating for the items in this measure.

The factors that were identified critical for health information usefulness are: (1) the system should provide up to date and complete information, (2) the system should consume appropriate amount and types of resources when it functions, (3) unnecessary elements should be eliminated from the user interface without significant information loss, and (4) the user should customize system interface to his preferences.

The factors that were identified critical for health information effectiveness are: (1) the system should be flexible for users to achieve their work goals and tasks, (2) the system should enable users to complete their work tasks accurately, (3) the system should be consistent in achieving different work tasks, (4) the system should provide the users with feedback on completing their tasks, (5) the system should provide the user with help to solve problems and recover from errors, and (6) the system should enable to complete their tasks with minimal number of errors.

The factors that were identified critical for health information efficiency are: (1) the system should enable users to complete their work tasks timely, (2) the system should enable users to complete their work tasks with the available resources, and (3) the system should enable users to complete their tasks with minimal action.

The factors that were identified critical for health information satisfaction are: (1) the system should be attractive to use and (2) using the system in performing the work tasks is pleasing. Results from analysis of variance (ANOVA) did not report any significant difference between female ratings for this measure. Also, there is no significant effect of the flow of experience with using computers or

Medical Information Systems on the respondents' rating for all items in this measure.

The factors that were identified critical for health information productivity are: (1) the system should increase users' productivity; (2) the system should enable users to complete their work tasks with the available resources, and (3) the system should enable users to complete their tasks with minimal loading time.

In addition to identifying the critical factors of Medical Information Systems usability, the research also investigated the attitudes of the study subjects towards using Medical Information Systems and their behavioral intention to use such systems. The results reported an average rating of (4.2) for the three attitude used in the study. The sample subjects also reported an average of (4.0) as rating for the three variables used to measure their behavioral intention to use Medical Information Systems.

Analysis of Variance (ANOVA) results report a significant effect of flow of experience using computers on the sample reported attitudes towards using Medical Information Systems (p value=0.02).

V. DISCUSSION AND CONCLUSION

In this paper, an extensive literature review is conducted. A set of customized usability measures is defined. A survey questionnaire tool is designed. A pilot study is conducted to assess the content validity, clarity and relevance of the survey questionnaire elements. A revised version is administered to a sample of medical staff working in public and private hospitals. Preliminary results show that all proposed usability measures except those of learnability are considered critical and may influence the user's intention to interact with the health information systems.

In addition, the study findings indicate that the adoption of Medical Information Systems in Saudi Arabia is at its infancy stage; since more than 25% of the respondents have reported that they have no experience with any Medical Information Systems at all and more than 22 % reported they have less than one year experience with Medical Information Systems.

In general, there is no significant effect of the personal characteristics of the study sample on their rating of the importance of the different identified determinants of Medical Information Systems usability measures, with the exception of flow of experience using computers which has shown a significant effect on the item: "the system should maintain a specific level of performance in case of being faulty".

ACKNOWLEDGMENT

The author would like to acknowledge the support for this research provided by Deanship of Scientific Research: King Faisal University as a part of the research grant (#130090).

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