

Evaluating the Usability of Hospital Information Systems Based on ISO 9241-10 Standard: A Cross-Sectional Study

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Abstract

Aim: This study aimed to assess the usability of HISs from users' viewpoints based on ISO 9241-10 standard.

Methods: This study was a descriptive and cross-sectional study that was conducted in 2019. It was filled out by 227 end-users, including 165 clinical and 59 administrative staff of Imam Khomeini, Mostafa Khomeini, and Taleghani hospitals selected randomly. Data were collected using the standard Iso-Metric 9241-10 questionnaire. The content validity and reliability of the questionnaire were assessed by experts' opinions and test-retest method, respectively. Finally, the findings were analyzed using descriptive statistics (mean value, standard deviation, and frequency) through SPSS-23 software packages.

Results: Based on the results, 56% of HISs users in the surveyed hospitals were somewhat satisfied, with the total average of all scores being equal to 2.8 from 5. The results suggested that the highest scores were found for the criterion of "controllability," while the lowest scores were associated with "suitability for individualizations" and "self-descriptiveness," respectively.

Conclusion: The HISs users' satisfaction was considered relatively desirable in terms of functionalities factors. Therefore, user-friendliness, flexibility, and web-based capabilities are suggested as the most important requirements that must be taken into account for enhancing usability and adoption of HISs.

Keywords: Hospital information system, Evaluation, ISO 9241/10, Standard

In the healthcare industry, Hospital Information Systems (HISs) can increase efficiency, productivity, and safety and save considerable amounts of expenditures (1). The HIS is a Local Access Network (LAN) at the hospital, which integrated all hospital departments through optimal information sharing. These systems enable healthcare facilities to improve information management processes including, gathering, storing, retrieving, manipulating, and exchanging data within the healthcare environment (2). HIS is an information infrastructure used to improve the quality of care by accelerating and accurately performing tasks, increasing safety, and reducing error. HISs deal with administrative, financial, and clinical aspects of healthcare facilities. The importance of these systems originates from their role in providing timely and accurate information for diagnosis, treatment, reporting, research, and medical decision-making purposes (3, 4).

However, despite the many advantages, HISs may face some serious problems that prevent their successful implementation. As such, these systems would work efficiently when their limitations and flaws are detected through an effective evaluation, which may be either formative or summative (5). Evaluation refers to measuring or discovering characteristics of HISs in the system development life cycle (SDLC). Indeed, continual evaluations before, during, and after implementing these systems are required to detect and resolve their shortcomings (6).

One of the most important quality criteria in the evaluation of information systems (ISs) is usability testing, which assesses its user interface (UI) characteristics through the involvement of end-users (7, 8). The usability of a system allows its user to perform their tasks safely, effectively, efficiently, and satisfactorily. Poor usability leads to reduced acceptance of HISs, increased errors, reduced user performance, which eventually threatens patients' safety (9). Also, if an information system cannot meet users' basic expectations, it will gradually lose its reliability, and finally, its efficiency will diminish (10). Many failures related to information systems are due to the limited usability of these systems, which can cause problems for users to interact with them. So it seems that it is inevitable to evaluate the usability criteria of any software product to ensure its adaptation to end-users requirements (11, 12).

The usability evaluation directly influences the amount of productivity, error rate, fatigue, and user satisfaction, which are the critical criteria for accepting an information system. The low availability of health information systems fails the effective and efficient use of these systems by users (6). Given that HIS packages are already purchased in surveyed hospitals, their flexibility and customization to meet the actual user's requirements and ongoing organizational processes are of utmost importance. Therefore,

this study aimed to evaluate the HIS usability from their users' perspective.

Method

This is an applied, cross-sectional study conducted in three public teaching hospitals (Imam Khomeini, Mostafa Khomeini, and Taleghani hospitals) affiliated to Ilam University of Medical Sciences (west of Iran) in 2019.

The instrument used for data collection is a usability questionnaire based on ISO 9241-10 containing seven main criteria and 36 components. The main research criteria included suitability for the task, self-descriptiveness, controllability, conformity to user expectations, error tolerance and suitability for learning (each containing five components), and suitability for individualization (with six components) (Table 2). The questionnaire was designed in three sections. The first section included a brief introduction to elucidate the research goals for respondents. The second section included demographic information questions. The third section of the questionnaire was designed to evaluate HIS modules based on ISO 9241-10 standards. The content validity of the questionnaire was assessed based on reviews and views by a panel of experts, including two experts in Health Information Management (HIM) and two experts in Medical informatics. Test-retest reliability (with a 10-day interval) was performed to determine the reliability of the questionnaire.

The questionnaires were distributed among 168 clinical (laboratory (21), radiology (18), and nursing (129)) and 59 nonclinical (financial-administration (45), health information management (9), and information technology (5)) staff in selected hospitals based on a random sampling method. They were asked to express their experiences about and satisfaction with these criteria and components through a five-level Likert scale (very high = 5, high = 4, medium = 3, low = 2, very low = 1).

The collected data were introduced into a Statistical Package for the Social Sciences (SPSS) software version 23, using descriptive statistics including frequency and relative frequency intervals. The results were provided as mean scores of users' satisfaction with HIS sub-systems in each nonclinical and clinical department at three selected hospitals.

Results

The findings of this study are categorized into four sections as follows:

1. Demographic and socioeconomic characteristics of participants

The findings from the present study showed that from 227 respondents who filled out the questionnaire in selected hospitals, 51 % were men and 49% were women. A total of 38 % of respondents had high school diplomas or lower educational levels, while 43.5% had bachelor's degrees and 18.5 % were graduated with a master's degree or higher. According to the data collected from the selected hospital, 43.5 % of respondents were younger than 30, while 34 % were between 30 and 40 years old, 14.5 % were between 40 and 50, and 8 % were older than 50. Also, 74% of respondents were clinical users, while 26% of respondents were nonclinical.

Table 1: Demographic and socioeconomic characteristics of participants

Hospital name					
Imam Khomeini		Mostafa Khomeini		Taleghani	
Sex		Sex		Sex	
Male	42	Male	38	Male	36
Female	52	Female	40	Female	19
Age intervals		Age intervals		Age intervals	
20-30	48	20-30	32	20-30	19
30-40	26	30-40	24	30-40	27
40-50	16	40-50	12	40-50	5
50<	4	50<	10	50<	4
Degree of education		Degree of education		Degree of education	
Under the diploma	2	Under the diploma	3	Under the diploma	7
Diploma	31	Diploma	21	Diploma	23
Bachelor	43	Bachelor	36	Bachelor	19
Masters	14	Masters	10	Masters	4
PH.D	4	PH.D	8	PhD	2
Department		Department		Department	
Financial – Administration	12	Financial – Administration	12	Financial - Administration	21
Health Information Management	2	Health Information Management	5	Health Information Management	2
Information Technology	1	Information Technology	2	Information Technology	2
Laboratory	7	Laboratory	6	Laboratory	8
Radiology	6	Radiology	5	Radiology	7
Nursing	27	Nursing	48	Nursing	54
Employment status		Employment status		Employment status	
Permanent	25	Permanent	18	Permanent	14
Contractual	48	Contractual	32	Contractual	21
Non-permanent	21	Non-permanent	28	Non-permanent	20
Total	94	Total	78	Total	55

Table 2: Usability evaluation of hospitals by individual components

Criteria	Components	Imam Khomeini	Mostafa Khomeini	Taleghani	Sum	criteria	Components	Imam Khomeini	Mostafa Khomeini	Taleghani	Sum
Controllability	Easy and fast return to start menu	3/3125 ±1/3893	4/2625 ±1/2512	3/0196 ±1/2408	3/4688 ±1/3308	Suitability for the tasks	Support the user to perform all daily tasks	3/3239 ±1/4552	3/0961 ±1/2318	4/1314 ±1/4318	3/2962 ±1/2158
	Stop running modules at any time	3/1705 ±1/4597	3/2691 ±1/2536	2/7843 ±1/5787	3/0746 ±1/2108		Matching data entry with user tasks	3/2727 ±1/4165	2/9756 ±1/2665	3/0212 ±1/2165	3/0898 ±1/2468
	Easy to navigate between screens	3/4886 ±1/2828	3/5812 ±1/4589	3/2157 ±1/4326	3/4285 ±1/1218		Crossing minimal bottlenecks to perform a task	3/0909 ±1/5166	3/5632 ±1/2165	3/6667 ±1/4615	3/4403 ±1/4532
	Go through a set of fixed steps to perform tasks	3/2670 ±1/5051	3/6842 ±1/6658	3/1569 ±1/5280	3/3693 ±1/2548		Display all required information on one page	2/8125 ±1/4828	3/0132 ±1/4228	2/7255 ±1/6132	2/8504 ±1/5328
	Enter a letter, character, or code to access menu items quickly	3/0852 ±1/5743	3/0269 ±1/5128	2/9020 ±1/4318	3/0047 ±1/1208		Easy access to needed commands to perform tasks	2/9773 ±1/5746	2/7724 ±1/5356	2/6863 ±1/4353	2/28128 ±1/3452
Conformity to user expectations	Easily accomplish the tasks due to the well designed and coordinated software	2/8011 ±1/6596	2/9686 ±1/4456	3/3137 ±1/5936	3/0278 ±1/4212	Self-descriptiveness	Equipped with data dictionary and metadata	2/9034 ±1/4567	3/0125 ±1/2588	2/5098 ±1/3225	2/8082 ±1/5213
	Estimation of the required time to perform the task	2/9489 ±1/4551	3/0154 ±1/2698	2/9020 ±1/1533	2/6554 ±1/1021		Comprehensibility the meaning of messages and commands	3/2102 ±1/3633	2/8858 ±1/3563	2/9020 ±1/3602	2/9993 ±1/4328
	Lexical and semantic integrity in different sub-systems	3/0625 ±1/2054	4/0236 ±1/9528	3/0 ±1/2165	3/3620 ±1/6528		Provide practical examples to explain tips	2/5966 ±1/4665	2/6932 ±1/2368	2/2157 ±1/268	2/5018 ±1/3654
	Use the same keys to perform specified tasks	3/1932 ±1/5624	3/6612 ±1/1128	2/8431 ±1/4051	3/2325 ±1/3458		Predictable menus function	2/8693 ±1/5047	3/2669 ±1/4123	2/7451 ±1/1973	2/9604 ±1/2132

Criteria	Components	Imam Khomeini	Mostafa Khomeini	Taleghani	Sum	criteria	Components	Imam Khomeini	Mostafa Khomeini	Taleghani	Sum
	Display issued messages in a specified part of the screen	2/2045 ±1/4518	2/8712 ±1/3218	3/0588 ±1/4304	2/7115 ±1/6558		Clarity of screen data fields and commands	3/1875 ±1/4957	2/5687 ±1/1288	2/8824 ±1/2334	2/8789 ±1/1568
Suitability for learning	Quick and easy learning to work with software	2/9034 ±1/4562	3/8614 ±1/4888	2/5098 ±1/3325	3/0915 ±1/4156	Error tolerance	Request user approval when performing tasks	3/6477 ±1/4816	3/0215 ±1/4828	3/8235 ±1/3579	3/4975 ±1/4318
	Easy to re-learn after no long-term use of the system	3/2102 ±1/3633	3/4333 ±1/4558	2/9020 ±1/3602	3/1818 ±1/3569		Provide useful information about getting out of the wrong situation	3/2670 ±1/46668	2/9654 ±1/3658	2/7255 ±1/04074	2/9859 ±1/5638
	Access the description to use the system when needed (Online or offline Help)	2/5966 ±1/4660	3/7855 ±1/1128	2/2157 ±1/2696	3/4688 ±1/3308		System alert about potential error situations	3/1591 ±1/5557	2/8965 ±1/2688	2/4510 ±1/33137	2/8355 ±1/3458
	Uses the software at first without asking colleagues	2/8693 ±1/5047	1/8852 ±1/2238	2/7451 ±1/1978	2/8659 ±1/2463		Quick identification of the data entry errors	2/9545 ±1/5499	3/1256 ±1/6558	2/9608 ±1/5499	3/0136 ±1/2456
	Recall details and tips for proper use of the system	3/1875 ±1/4597	4/0121 ±1/4765	2/8824 ±1/2434	3/3606 ±1/5623		Easy return to the previous (last) action in case of a mistake	3/2273 ±1/4940	3/3326 ±1/4221	3/074 ±1/4119	3/2113 ±1/1325
Suitability for individualization	Conformity of field order with the current process	2/6193 ±1/6133	3/4586 ±1/46588	2/3922 ±1/5725	2/8233 ±1/4236	Suitability for individualization	Customize forms, screens, and menus as desired by the user	2/4795 ±1/3288	2/8645 ±1/5485	2/3137± 1/40699	2/5525 ±1/3308
	Set up input/output devices tailored to user needs	2/6818 ±1/5898	3/1536 ±1/4828	2/4118 ±1/3889	2/8090 ±1/4369		Adjust the amount of information on the screen tailored to user needs	2/7386 ±1/5928	2/6912 ±1/5868	2/2549 ±1/53419	2/5615 ±1/3308
	Adjust the system speed according to the tasks	2/3068 ±1/4490	2/9656 ±1/7688	2/1373 ±1/2491	2/4699 ±1/1245						

2. Usability evaluation of hospitals

This study evaluated the software usability of HISs who applied a similar software package related to Rayavaran Development Company based on seven ISO Metric criteria and a total of 35 components. The following table provides the results of evaluating HIS sub-systems at three hospitals, including Imam Khomeini, Mostafa Khomeini, and Taleghani.

According to Table 2, the highest usability score of HIS systems, from a total of 36 components, was related to "Easy and fast return to the start menu"(4/2625±1/2512) while the lowest score was assigned to the "Uses the software at first without asking colleagues" (1/8852 ±1/2238) in Mostafa Khomeini hospital.

3. Usability evaluation of hospitals by individual criteria

The results of the evaluation of sub-systems by the criteria showed that in Imam Khomeini and Taleghani hospitals, the highest score belonged to controllability (3/56, ±1/5891) and suitability for the tasks (3/10, ±1/4971)

respectively. On the other hand, the suitability for individualization criterion in Imam Khomeini (2/04, ±1/3546)and in Taleghani (1/80, ±1/2980) hospitals was obtained the lowest. In Mostafa Khomeini hospital, the highest and lowest scores were assigned to the controllability (3/89, ±1/4489) and suitability for learning criteria (1/83, ±1/4822). Table 3 presents the HIS evaluation per criteria.

4. Usability evaluation for all hospitals by criteria

The results of evaluating sub-systems for all three hospitals indicated that the controllability criterion obtained the highest scores (3/83). On the other hand, suitability for the individualization criterion (2/03) showed the lowest score. The mean scores of the other criteria were as follows: Suitability for the tasks (3/15), Self-descriptiveness (2/38), Conformity to user expectations (3/12), Error tolerance (sensitivity) (3/10), and Suitability for learning (2/54). The following chart depicts the average total score of the hospital usability software (Figure 1).

Table 3: The average ISO criteria scores in selected hospitals

ISO Criteria	Imam Khomeini hospital	Mostafa Khomeini hospital	Taleghani hospital
Suitability for the task	3/08, ±1/4871	3/28, ±1/4985	3/10, ±1/4971
Self-descriptiveness	3/02, ±1/4451	2/08, ±1/5626	2/04, ±1/4194
Controllability	3/56, ±1/5891	3/89, ±1/4489	4/01, ±1/4444
Conformity to user expectations	3/31, ±1/3235	3/04, ±1/4792	3/02, ±1/3687
Error tolerance	3/06, ±1/4988	3/25, ±1/5254	3/0, ±1/4197
Suitability for individualization	2/04, ±1/3546	2/26, ±1/4652	1/80, ±1/2980
Suitability for learning	3/39, ±1/4541	1/83, ±1/4822	2/41, ±1/4310

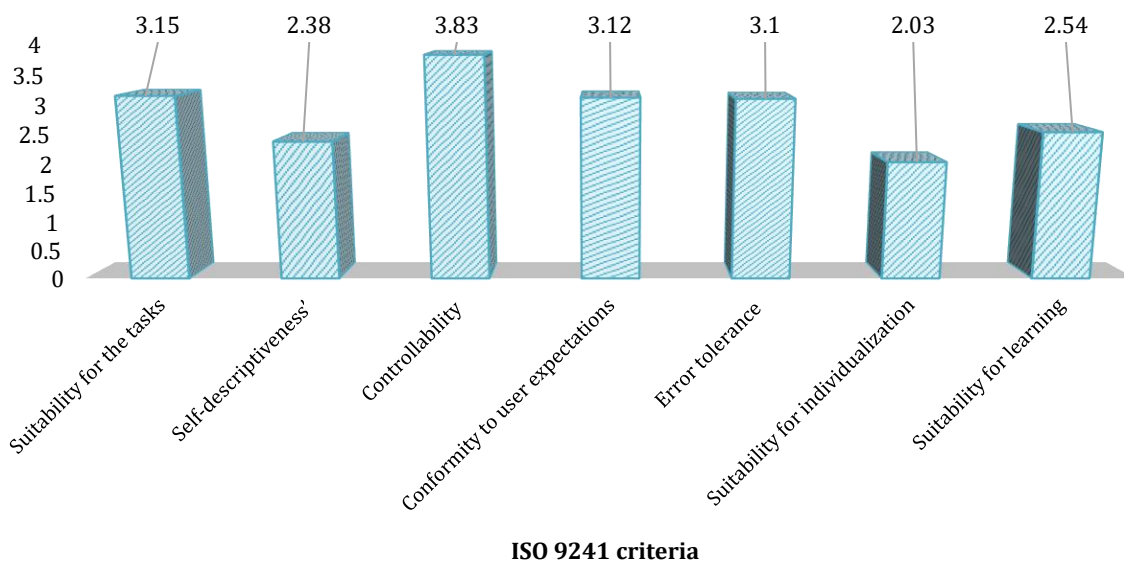


Figure 1: Usability evaluation for all of the three hospitals by criteria

Discussion

Despite the widespread use of HISs, these systems suffer from usability problems. The usability criteria can be improved by adhering to existing standards and principles (13). In this study, the usability of HISs in the surveyed hospitals was assessed from their users' perspectives (clinical and nonclinical views), and finally, the highest and lowest scores were obtained for controllability and suitability of individualization criteria with 3.83 and 2.03, respectively.

Controllability refers to the feature of an information system that allows a user to maintain control over the whole course of the interaction (14). Its main aspects include the use of username and password, terminal procedures, account lockout, audit trail, denial of services (DOS), firewalls, virtual private networks (VPNs), and cryptography (encryption-decryption) technology to maintain security and confidentiality of information. In the present study, users were 77% satisfied with the "controllability" criterion, which obtained the maximum usability score (average score = 3.83). This suggests that the HISs in the selected

hospitals are under user control. The satisfaction level of this criterion in the Pasandideh et al. (15) study was 62.3% (average score=3.16). In the study by Safdari et al. (16), a mean score of 3.09 was reported for this criterion.

The capability of dialogue despite the existence of system bugs, but to continue operating properly or with minimal corrective requirements (14). Identifying software errors (bugs) and automatic repair or alerts to users is essential for HIS modules. In the present study, this criterion was achieved to be desirable (average score = 3.10). The approval level of HIS users regarding the "Error tolerance" criterion in Pasandideh et al. study (15) was 59.9% (average score = 3). In this regard, Sheikhtaheri et al. (17) suggested that HISs should be easily and quickly reversible and flexible for their users to revise the errors and wrong information. This feature ensures the information system continuity process.

Conformity to user expectations as one of the seven criteria demands that an application behaves consistently with the user expectations, task knowledge, education, experience, and commonly accepted conventions (18). The level

of satisfaction among system users with the "conformity to user expectations" criterion had an average score of 3/12. Pasandideh et al. (15) reported a 63.12% satisfaction level with a 3.15 average score. Also, Saeedbakhsh et al. (19) reported a 74% satisfaction level, and Ghaderi Nansa et al. (20) found a 2.96 average score.

Suitability for individualizations refers to the flexibility of the system interface environment under the user expectations, individual needs, and skills (14). Users in this study were 41% satisfied with the "suitability for individualizations" criterion in all of the three hospitals, which showed the lowest score (average score = 2.03). Pasandideh et al. (15) reported a 57.63% satisfaction level with a 2.86 average score. Also, Saeedbakhsh et al. observed a 74% satisfaction level. Ghaderi Nansa et al. (20) reported an average score of 2.56, and Saeedbakhsh et al. (19) concluded that HIS users are 53% satisfied with the system customizable.

Suitability for the task refers to the system that supports users in the effective and efficient completion of the task (14). The obtained results showed that HIS system users have been 63% satisfied with "Suitability for the task" with an average score of 3.15. The system users in the Pasandideh et al. (15) study were 65% satisfied with the average score of 3.26 for this criterion. Satisfaction level with the same criterion was previously reported by Saeedbakhsh et al. (19) to be 68%, while Ghaderi Nansa (20) found an average score of 2.93 for that.

Suitability for learning means providing support and guidelines to the user through online or offline help and instructions (18). The level of satisfaction among system users with the "suitability for learning" criterion was 51%, with an average score of 2.54. Pasandideh et al. (15) has reported a 57.63% satisfaction level with a 2.86 average score. Ghaderi Nansa et al. (20) observed an average score of 2.93, while Saeedbakhsh et al. (19) reported 68% satisfaction with this criterion. Providing

online and offline "help" educational recommendations to answer the potential users' questions to work with different parts of the system is also critical to the effective learning of system users. Provision of this functionality for assisting users is recommended to prevent misunderstandings, avoid unnecessary contact with the system administrator, and save time devoted to learning the system (21).

Self-descriptiveness is defined as the understandability of screen contents using metadata, data dictionary, and multilingualism programs (22). It can be said that the self-descriptiveness criterion of HISs in the selected hospitals failed to address the users' requirements. Thus, HIS designers should use applicable data dictionaries and metadata to normalize data fields and information content. Besides, vague abbreviations and phrases should be avoided for explaining the information content. In this regard, Ehteshami et al. (23) stated that upon user request, the software must display basic information about conceptual and functional aspects of the program.

So far, several studies (24-28) have discussed and highlighted the influence of HIS usability evaluation, which revealed some problems with undesirable consequences on the system functionality. Guo and et al. (29) assessed the usability of an electronic medication administration record application, whereby 60 usability problems were identified. They reported that these problems can decrease users' efficiency, effectiveness, and satisfaction. Nabovati et al. (13) evaluated the usability of the laboratory and radiology modules of a HIS. They found that User Interface (UI) interactions had many major problems, delaying physicians' access to the results. In another study, Van Engen-Verheul et al. (30) assessed the data entry module of an Electronic Patient Record (EPR) system. They observed that 40% of the navigational actions of experts had deviated from the predefined following system action,

mainly due to lack of compliance between the system design and user expectations.

The results of the present study revealed that the HISs in the selected hospitals had slightly desirable compliance with ISO 9241-10 standard criteria. The researchers recommend that certain functionalities of the system incongruent with the users' requirements and demands be redesigned. The strength of this study was a large number of users randomly selected, enabling the comparison of the users' demographic characteristics. However, the lack of emphasis on a specific HIS module (such as RIS, LIS, NIS, etc.) was the research limitation. To create an in-depth analysis, it is suggested that further research be performed to evaluate the usability of each HIS module separately. Secondly, the low level of HIS user awareness and knowledge about practical and technical aspects of their modules was another limitation, which can be resolved with effective training courses.

Conclusion

According to real users' views, the surveyed HIS, implemented in the selected hospitals, had usability problems in terms of user-friendliness, customization, internet access, help menu, and guidelines. In conclusion, to resolve these usability problems, the following suggestions are presented: 1- It is better to create a HIS in web-based platforms to provide interoperability across different HISs for optimal sharing of information; 2- it is suggested to use more than one language in the design of HIS contents (multilingualism programs); 3- It is better to use general Data Dictionary, metadata as well as specialized (medical) terminology for defining and normalizing contents; 4- It is recommended to design flexible HIS infrastructures to be more adaptable to the dynamic healthcare environment; 5- It is recommended to use dynamic menus, animations, and colored graphic pictures in the design of different parts of the system; 6- It is suggested to insert a special tab

for Internet connection (web-based HIS) to provide online help program for resolving possible ambiguities, and 7- It is better to pay more attention to the provision of online" help" recommendations.

Disclaimer Statements

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Authors' contributions: M.Sh and H.K-A designed the study plan. M.J designed the questionnaire and implemented the evaluation. O. Y performed the statistical analysis and finally, M. Sh and H.K-A reported the results.

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