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A combination of three scales for measuring user-perceived usability of a clinical information system: which approach produces the most informative results?

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ABSTRACT

Introduction: For the first time in Iran, a kidney stone clinical information system (CIS) has been designed to manage and calculate and visualize patients' kidney stone risk profiles. Nevertheless, the usability of this system has not been evaluated yet. Medically, this study aims to evaluate the user-perceived usability of the kidney stone CIS. Technically, the current study aims to determine which user-perceived usability testing approach produces the most informative results about the usability of this system.

Material and Methods: Three questionnaires, including system usability scale (SUS), software usability measurement inventory (SUMI), and post-study system usability questionnaire, were applied to carry out the study. A total of 15 users of the kidney stone CIS participated.

Results: The findings revealed that the system is of medium usability. Moreover, of the three methods used, the SUMI echoes the comments of the end-users. Despite the medium usability of the system, it was comprehensive in terms of proper data collection and storage, as well as reporting. The interface design, the lack of appropriate guidance, the time-consuming data entry, and the slow reporting system were aspects needed improvement.

Conclusion: Using a combination of tools is recommended for usability evaluation. Since there is much space in the Global and each sub-scale, whereby measures may improve with SUMI, this research recommends its use for future evaluation of the kidney stone CIS.

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INTRODUCTION

Providing quality health care services can significantly improve public health. In this regard, information technologies and information systems are essential in providing effective and timely health care services [1, 2]. Recent advances in information technology and computer science have led to the creation and development of information systems in various fields. In health care settings, these systems are known as health information systems and are used as supportive tools to facilitate managerial and clinical tasks [3]. Such systems have the potential to improve patient safety by providing timely access to information during clinical decision-making [1, 2]. Furthermore, these systems may help decrease mistakes, cut costs, improve service delivery [4], and support health care interventions [5]. However, studies have shown that, for various reasons, some of these systems cannot reach acceptable goals [6]. Usability issues are one of the leading causes of these types of failures [6-10]. Usability refers to the degree of effectiveness, efficiency, and satisfaction of users of a product to achieve well-specified goals and is a product of the interaction between users, products, tasks, and the environment [11].

Usability as a software quality element must be considered when designing an interactive health information system [12] because the poor usability of a system can lead to a reduction in system efficiency and effectiveness, which in turn can decrease user satisfaction and trust in the system [13] and even cause a crisis [14, 15]. As usability represents the most prominent aspect of the user-perceived quality of an information system [16], it is recommended to continuously evaluate the usability of health information systems to explore and solve possible problems [6-10]. In recent years, research into the user-perceived usability evaluation of health information systems has become prominent in the research agenda and standard tools designed to assess this aspect of the usability of information systems [17].

Standard tools for evaluating user-perceived usability

The system usability scale (SUS) questionnaire [18] is a tool to evaluate a wide variety of user interfaces of different types of systems and software [19, 20]. Comprehensibly, users participate in the evaluation, and it is cost-effective because of free access. However, the shortcoming of this tool is that it shows the system's overall usability and does not identify the problem area. Moreover, since the 'good' score is near the top of the scale, it will not discriminate between competing systems well above the average.

Another tool used for usability evaluation is the software usability measurement inventory (SUMI) tool which evaluates the usability of a system based on the users' point of view [21]. This scale is mentioned in the ISO 9241 standard as a recognized method of testing user satisfaction [22] and has been used in several studies so far [23-25].

Post-study system usability questionnaire (PSSUQ) is another tool developed and used extensively at IBM's design center [26]. It measures information quality, user interface quality, system usefulness, and overall system usability.

The kidney stone clinical information system (KSCIS)

For the first time in Iran, a clinical information system (CIS) has been designed for calculating and visualizing kidney stone risk profiles of patients referring to the urology and nephrology research center (UNRC) of Shahid Beheshti university of medical sciences.

Currently, all health care practitioners, including physicians, nurses, laboratory experts, and other centers affiliated with the UNRC, have access to the software (Fig 1).

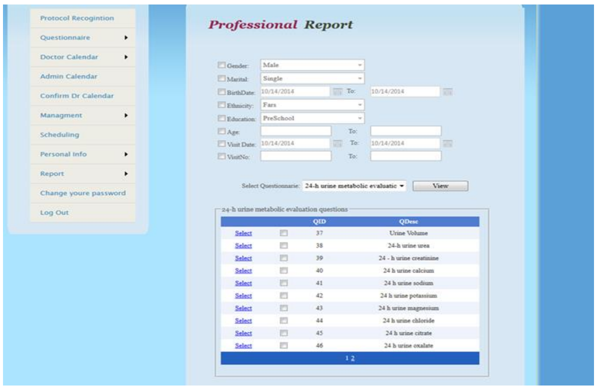

Fig 1: The Sample image of reporting environment of the KSCIS

There are two sets of goals intended for this research. Regarding, that the usability of this CIS has not been evaluated yet; thus, the medical goal of this study is to evaluate the user-perceived usability of the system.

The technical goal is to determine which approach to testing user-perceived usability produces the most informative results to make future evaluations of this system more efficient. Undoubtedly, each method will have its characteristic strengths and weaknesses, but the question arose: Which method is highly recommended for the future evaluation of this system?

MATERIAL AND METHODS

The study population

A group size of 3-20 participants for usability testing studies is typically valid [27]. Regarding that reliable results and effective use of SUMI, PSSUQ, and SUS need a minimum of 12, 8-12, and 8-12 participants [28, 29] respectively, so, in this study, a total of 15 users of KSCIS participated.

Research tools

Three sets of questionnaires, including PSSUQ (16 items), SUMI (50 items), and SUS (10 items), were applied to conduct the present study.

The SUS scale consists of ten questions with response options presented in a Likert scale format. Each question has five possible responses (between 1 and 5, where 5=strongly agree). The total score obtained with this questionnaire is between 0 and 100, which reflects the system's overall usability, and a score above 68 indicates an acceptable level of user-perceived usability [18]. It has been used in over 1300 studies so far [30]. Tullis and Stetson have shown possibly, to get reliable results with a sample of 8-12 users [27].

The SUMI questionnaire contains 50 questions in five subscales: Efficacy, Affect, Helpfulness, Control, and Learnability. SUMI questionnaire can provide global and subscales scores. A Global score indicates the overall usability of the system. The SUMISCO software, which refers to the extensive standardization SUMI database, was used to analyze the data and calculate the scores of each subscale [21]. Reliable results and effective use of this tool require a minimum of 12 users, and a usability score is calculated based on the users' responses [29].

The PSSUQ tool consists of 16 questions reflecting overall system usability, system usefulness, information quality, and user interface quality. The PSSUQ is scored on a 7-point Likert scale that ranges from 1 (strongly disagree) to 7 (strongly agree). A lower score indicates better system performance. This tool has been reported in various studies [31-33]. A sample of 8-12 users will yield reliable results [27].

Procedure

Each participant was asked to perform six tasks related to the software's intended functions. These included: finding the name of patients in the menu system, retrieving information on patient admission, retrieving the patient's disease and medication history, retrieving the patient's medical condition details, and entering patient information into the system. All of these tasks were done by the users themselves and under the supervision of the system expert. The expert was allowed to guide the user only in case of confusion.

Immediately after successful completing the mentioned tasks, the participants filled in the three questionnaires in printed format, including PSSUQ, SUMI, and SUS. All the participants got the three questionnaires in the same order. Participants were also interviewed privately to state their general opinions about the system. Their opinion was summarized and recorded. All of these steps were done privately. In this regard, there was no possibility to speak and exchange views between the participants, as well as to hear the opinions of the others.

Data analysis

SUMISCO software was used to analyze the data from the SUMI questionnaire. Besides, SPSS 18 software was used to analyze the data obtained from SUS and PSSUQ questionnaires. Furthermore, the Pearson correlation test was used to assess the relationship between the scores of the questionnaires. The independent t-test was used to compare the scores between different user groups.

RESULTS

Fifteen users with an average age (27.9±8.50) participated in the system usability evaluation. The results of the SUMI questionnaire analysis are presented in Table 1.

The sub-score above average accordingly belongs to Affect (55.47±11.69), which indicates that the users liked the interfaces and the idea of the tool; Helpfulness (52.0±10.34), which refers to the user's perceptions that the software communicates helpfully and assists in the resolution of operational problems; Learnability (53.40±9.69) that indicates the ease with which a user can get started and learn new features of the product. The mean score obtained in the Control (48.67±8.34) and Efficiency (49.80±12.47) subscales are less than average. Indicatively, the system did not respond to user inputs and commands as expected, as well as the system assistance to users, is insufficient.

Table 1: The results of the system evaluation based on the SUMI scale

Category	Mean	SD	Median	IQR*	Min	Max
Global	50.73	9.61	51.0	16.0	37	68
Efficiency	49.80	12.47	50.0	19.0	22	71
Affect	55.47	11.69	60.0	19.0	39	71
Helpfulness	52.00	10.34	53.0	10.0	26	68
Control	48.67	8.72	48.0	11.0	28	62
Learnability	53.40	9.69	52.0	13.0	35	70

The global score of the system was slightly above the average, indicating that user satisfaction is higher than average and the usability of the evaluated system is comparable to successful commercial systems (Fig 2).

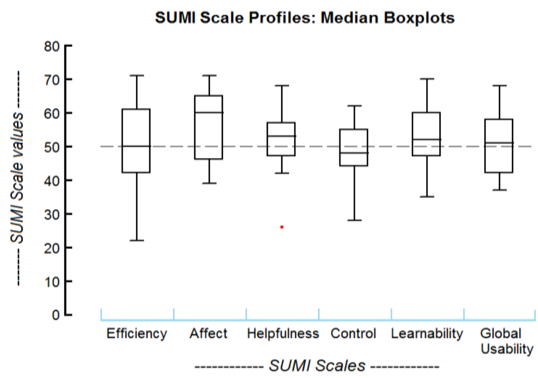

Fig 2: The comparison of quantitative usability measurements

Looking at the distribution of responses to the individual items of SUMI, this study found that six items have exceptional distributions that yield statistically significant probability values compared to the expected values of the reference SUMISCO database (Table 2). Item 7 yields a distribution better than the database, suggesting that users enjoy their time using the software (the verdict for this item is 'good'). Item 40 yields a distribution worse than the database, suggesting that it is not true that users feel they will never learn to use all that is offered in the software (so the verdict is also 'good').

Table 2: Statistically significant substantial items of SUMI

Item no.	Description	Chi-Square	P-value	Verdict
7	I enjoy the time I spend using this software	6.904	. 968	Good
25	There is too much to read before you can use the software	6.259	. 956	Bad
34	The software allows the user to be economical with keystrokes	14.734	. 999	Bad
36	There are too many steps required to get something to work	14.592	. 999	Bad
38	Error messages are not adequate	7.247	. 973	Bad
40	I will never learn to use all that is offered in this software	11.159	. 996	Good
42	The software presents itself in an appealing way	9.106	. 989	Bad

The other items all yield a distribution worse than the database's expected values, showing why the users are barely above the mean for the Global scale. Interestingly, these per-item analyses are also echoed in the free-form comments made by users at the end.

The results of the SUS questionnaire are presented in Table 3. Based on the SUS questionnaire results, the mean system usability score was (70.67±14.80). The score based on the Sauro/Lewis rating [26] is in grade C.

Table 3: The Sauro/Lewis curved grading scale [26]

SUS Score Range	Grade
84.1–100	A+
80.8–84.0	A
78.9–80.7	A-
77.2–78.8	B+
74.1–77.1	B
72.6–74.0	B-
71.1–72.5	C+
65.0–71.0	C
62.7–64.9	C-

The usability testing results based on each item of PSSUQ, as well as the overall satisfaction with the usability, are presented in Table 4.

The result revealed that item 7 (Q7) has the best score (lowest) compared to other items, which demonstrates that "*the system error messages are easily understandable by the users.*"Furthermore, the findings showed that Q14 and Q15 have the highest scores. The score indicated that interface quality did not stand to users' preferences. Moreover, the results showed that overall the users are satisfied with the system's usability.

Table 4: The results of the system usability evaluation based on the PSSUQ tool

Category	Item	Scale Scoring Rule	Min	Mean (SD)	Max
System usefulness	Q1	Overall, I am satisfied with how easy it is to use this system	1	2.93 (1.438)	6
	Q2	It was simple to use this system.	1	2.60 (1.183)	5
	Q3	I was able to complete the tasks and scenarios quickly using this system	1	2.57 (1.505)	6
	Q4	I felt comfortable using this system	1	2.53 (1.060)	5
	Q5	It was easy to learn to use this system.	1	2.07 (1.033)	4
	Q6	I believe I could become productive quickly using this system	1	2.13 (1.457)	6
Information quality	Q7	The system gave error messages that clearly told me how to fix problems	1	2.79 (1.672)	6
	Q8	Whenever I made a mistake using the system, I could recover easily and quickly.	1	2.57 (1.399)	5
	Q9	The information (such as online help, on-screen messages, and other documentation) provided with this system was clear	1	2.73 (1.272)	5
	Q10	It was easy to find the information I needed	1	2.47 (1.407)	5
	Q11	The information was effective in helping me complete the tasks and scenarios	2	2.92 (1.084)	5
	Q12	The organization of information on the system screens was clear	1	2.80 (1.656)	7
Interface quality	Q13	The interface of this system was pleasant	1	2.79 (1.929)	7
	Q14	I liked using the interface of this system	1	3.00 (2.000)	7
	Q15	This system has all the functions and capabilities I expect it to have	1	3.00 (1.301)	5
Overall	Q16	Overall, I am satisfied with this system	1	2.43 (1.158)	4
Total				2.65 (1.089)	

Table 5: Scores of the subscales of the PSSUQ

Subscales	Min	Max	Mean (SD)
System usefulness (SYSUSE)	1	5	2.484 (1.059)
Information quality (INFOQUAL)	1.33	4.75	2.719 (1.135)
Interface quality (INTERQUAL)	1.33	6.33	2.933 (1.535)
Total	1.40	4.63	2.651 (1.089)

The overall satisfaction with the system's usability and the results derived from PSSUQ subscales are presented in Table 5. The SYSUSE had the best score (Mean of 2.48), and the interface quality had the worst score (Mean of 2.93) among the three subscales of PSSUQ.

A comparison of the questionnaires

Table 6 showed the results derived from the comparison between questionnaires. The Pearson correlation test showed a statistically significant relationship between SUMI global score, SUS score, and PSSUQ score ($p<0.05$).

Table 6: A comparison between questionnaires

		PSSUQ	SUS
SUMI	r	-0.842	0.677
	P-value	<.001	0.006
PSSUQ	r	1	-0.718
	P-value		0.003

To make a better comparison amongst the results derived from the PSSUQ questionnaire, by using (1), the researchers converted the PSSUQ scores range from 1-7 (lower scores=higher satisfaction) to a scale range from 0 to 100. This gave a score similar to SUS that a higher score indicates more valuable experiences:

$$PSSUQ = 100 - \left(\left(\left(\begin{matrix} Q1+Q2+Q3+Q4+Q5+Q6+Q7+Q8+Q9+ \\ Q10+Q11+Q12+Q13+Q14+Q15+Q16 \end{matrix}\right)/16\right) - 1\right) \times (100/6) \quad (1)$$

Its final score can range from 0 to 100, where higher scores indicate more acceptable usability.

Accordingly, the mean system usability score of (72.492±18.157) was derived from the PSSUQ questionnaire (Fig 3).

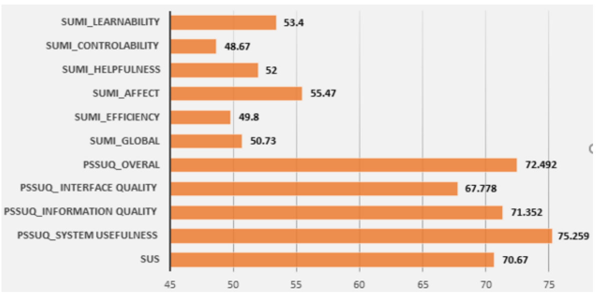

Fig 3: The comparison between scales and their subscales in a score range of 0-100

The horizontal bars in Fig 3 are not strictly comparable because the SUS questionnaire scores for each respondent were computed (following the suggested procedure by Brooke [18] from raw scores, which initially span a range from 10 (all negative responses) to 50 (all positive responses) and are simply fitted to a range of 0 till 100 by algebraic methods. The raw PSSUQ scores similarly span a range from 16 to 112 and are reversed and fitted to the range 0 to 100. In neither case do we know where the expected population mean occurs or how far above or below the expected population mean the transformed data for SUS or PSSUQ lie.

In contrast, the SUMI data is transformed by the scoring SUMISCO program using the typical standard score (z-score) procedure to yield distributions in which the expected population mean is 50.0 and the expected population standard deviation is 10.0, so the reader can see clearly where the obtained scales and subscales fall concerning the expected population parameters.

There are two open-ended questions at the end of the SUMI questionnaire where users have expressed their opinions on system usability strengths, as well as weaknesses that need improvement. Summarizing the users' opinions showed that the system was comprehensive in terms of proper data collection and storage, and reporting. The interface design of the system, the lack of appropriate guidance, the time-consuming data entry, and the slow reporting system were aspects that, according to the SUMI results, need to be improved.

DISCUSSION

To our knowledge, the present study is the first one that evaluates the usability of a clinical information system using the three questionnaires SUS, SUMI, and PSSUQ, and the same has not been done so far.

The findings revealed that the investigated system is of medium usability, and some strides need to be made towards its improvement. Similar results were obtained in a study evaluating the usability of dashboard for home care nurses [34] and a study on usability evaluation of a knowledge-based population health information system [35] using the SUS questionnaire.

Medical goal

Arising from the evaluation by the end-users, the following issues need to be addressed:

The “Affect” subscale showed the degree to which users like the computer system. The current research findings revealed that users are more satisfied with the “Affect” of the systemthan the other subscales. These findings are in line with the results of the usability assessment of Parkinson’s symptoms, in which the interviews revealed that most participants liked using the system [36]. Nevertheless, the mean score of “Affect” is slightly above the average, and software developers must consider software improvement to get better results.

The findings revealed that users are satisfied with the “Helpfulness” of the system as they have rated the system above the average. Nevertheless, end-users are still concerned with the system Helpfulness issues, which are yet to be improved.

The "Control" and "Efficiency" are closely rated by the users below the average, whereas the "Control" yielded the worst score. The "Control" dimension measures the extent to which the user feels that he/she controls the software, as opposed to being controlled by the software when carrying out the task. "Efficiency" measures the degree to which users feel the software assists them in their work. This implies that the KSCS did not appear to assist the user, and in general, users felt out of control using the software. Thus, it is recommended that the software developers must pay special attention to improving the system regarding the "Control" and "Efficiency" dimensions.

The interface is the most crucial part of a system [37] and directly impacts the user's interpretation of system quality [38, 39]. Nevertheless, in this study, the user interface based on both PSSUQ and SUMI questionnaires was of poor quality. Since the users' perception of the quality is more significant than the quality of the system itself, some actions should be taken to enhance the quality of the KSCS user interface and design a user-friendly system.

Regarding Learnability, users perceived the KSCS as learnable since the results revealed that Learnability has gotten satisfactory scores based on both PSSUQ and SUMI questionnaires and has been approved by both tools. Most notably, the Learnability score obtained from SUMI and PSSUQ is slightly above the average. This indicates a need for improvement and should not be disregarded by the system developers.

Technical goal

Comparing the three questionnaires used for this evaluation, it would appear that the PSSUQ is the least useful of all since it is unclear whether the values attained are at an acceptable level, nor by how much. This is not easy to analyze the importance of individual items from PSSUQ. A recent publication by Lewis may shed more light on these issues depending on the strength of expert reviews of this recently self-published book [40]. When the PSSUQ data are converted to a comparable scale to SUS, this study noted that the mean usability score is high (72.492/100) and that the standard deviation was also significant (18.157) so that PSSUQ is insensitive to data above the 68th percentile.

Although the SUS questionnaire was widely used, the narrowness of the scale at levels above the mean and the width of the standard deviation suggest that the scale was liable to distortion by a relatively small number of respondents. Although the SUS results agreed with the SUMI Global results in that users perceive the system to be above the population mean (by a tiny amount in both cases), the SUS results do not take the analyst much further. The current study noted that SUS is free (an advantage) and can be modified at will (a distinct disadvantage with regard to reported standardization data.)

The SUMI questionnaire is the longest of the three measures used, although its 3-point response surface to each item makes it easy to apply. It also produces the most detailed set of diagnostic data, which in our case was amplified in the users' free-form comments. The present study noted that in comparing experienced and naive users, the Affect dimension of SUMI is significant statistically, which is also true of the results with the SUS questionnaire. On examining the items making up SUS it was observed that eight out of the ten items are primarily 'Affective' themes, which would account for the correlation between the SUMI Affect and SUS. This comparison also brings into sharp relief that SUMI gives five times more information than SUS, namely the SUMI scale in addition to the Affect scale.

The current research also stated that unlike with the SUS and PSSUQ scales, there is space for plenty of room for improvement with all the SUMI scales. So while any re-development of the KSCIS might not result in much improvement with SUS and PSSUQ (because they are already near their theoretical maxima), with SUMI, we may expect improvement in other versions of the software to be reflected in reliable and steadily increasing values for the Global and sub-scales.

CONCLUSION

Several issues have been highlighted with the current version of the CIS. This study found that of the three methods used, SUMI echoes the comments of the end-users and allows us to place a numerical weight on these comments. This research also found that since there is much space in the Global and each sub-scale whereby measures may improve with SUMI, It seems preferable to use SUMI to evaluate further iterations of this clinical information system in the future.

AUTHOR'S CONTRIBUTION

SR, SV-H: conceptualization; SV-H, JK, SR: methodology; SR, SV-H: project administration; MT, ST: data curation; SR, MT, ST: formal analysis and investigation; SV-H, SR, JK: original draft preparation; SV-H: review and editing; SR: funding acquisition. All authors read and approved the final manuscript.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest regarding the publication of this study.

FINANCIAL DISCLOSURE

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ETHICS APPROVAL

The present research has been approved by the ethics committee of the Urology and Nephrology Research Center, Shahid Beheshti University of Medical Sciences (code: IR.SBMU.UNRC.1396.81).

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