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Usability evaluation of a national mobile- based automation system for pre-hospital emergency care (ASAYAR)

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A B S T R A C T

Introduction: Emergency Medical Services (EMS) is one of the vital links in the care chain, and its services need to be improved. These services can be available through mobile-based automation system, in which low usability level of these systems lead to decrease the acceptance, satisfaction, and confidence of users especially the emergency care team. The purpose of this study was the usability evaluation of a national mobile- based automation system among the pre-hospital emergency care team.

Material and Methods: This cross-sectional study was conducted on pre-hospital emergency care team members in Semnan and Shahroud Universities of Medical Sciences in 2022. The usability evaluation of the mobile- based EMS automation system was done using the Software Usability Measurement Inventory (SUMI) questionnaire. Multiple logistic regression models were used to analyze data.

Results: One hundred eighty-eight EMS team members from the 31 EMS centers in Semnan province participated in present study. The mean total usability score was 61.93±15.37, the highest mean score was related to the efficiency feature (67.19±19.85) and the lowest mean score was related to the learnability feature (48.21±29.29). There was a reverse and significant relationship between being a manager and the agreement with the usability (p=0.04, OR= -3.383, CI 95%=0.389-29549).

Conclusion: This study showed that although an automation system may be widely used in a country, its usability could be at a low level. In order to improve the different function of these systems, it is suggested to participate various clinical experts include prehospital emergency care team in all stages of designing and developing these systems.

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INTRODUCTION

Emergency Medical Services (EMS) are emergency services that provide instant and early pre-hospital treatment and stabilization for serious illnesses and injuries, as well as definitive care [1]. EMS is one of the most important components of the emergency and trauma care system in a country that provides medical response and transportation for the sick and injured people [2]. Also, EMS is one of the vital links in the care chain, and its services need to be improved to effectively transport patients from resource-constrained areas [3].

In recent decades, various mobile technologies have been designed to improve the quality of EMS service to exchange clinical information and then today the construction and use of digital information devices

such as smartphones and tablets are developing progressively [4, 5]. Over the years, automation systems have been increasingly used in time-sensitive or safety-critical settings [6]. EMS automation systems improve the performance of the emergency department and lead to make aware of the patient's condition during the transition to a hospital and prepare the required equipment and the medical staff to provide services [7].

Usability is one of the key elements of the information system quality [8]. The importance of usability measurement is investigating about the origins of the perceived efficiency or style, whether it is able to achieve the highest capacity to provide the best conditions for its users [9]. Usability features include satisfaction, usefulness, learning performance, ease of use, and learnability [10]. Usability evaluation enables the identification of specific problems in the user's interaction with the system [11]. In mobile application development, usability studies the simplicity, satisfaction, and elegance of interaction with an application [12]. On the other hand, the EMS team may encounter with some problems when using mobile tools in emergency missions. Previous researchers have found that a lack of usability consideration in the design of clinical data management systems leads to potential human-computer interaction issues, and excess workflow complexity that will reduce the efficiency of clinical and research procedures and the quality of patient care [13, 14].

Various studies have investigated the use of mobile-based technologies in the field of EMS. For example, Katayama et al. evaluated the effects of utilizing a smartphone app that empowers EMS staff to share information among emergency care teams regarding on-scene ambulances and hospital in Osaka City, Japan. They found sharing information between an ambulance and a hospital staff by using the smartphone app at the scene was associated with the reduced problem in hospital admission [15]. Tan et al. developed and evaluated a real-time traffic information-based emergency medical service system (RTIEMS) by utilizing sensor devices, webcam, 2.4 GHz ISM band RF module, ZigBee communication technology, GPS, Google Maps, and WiMAX mobile network. Experimental results confirmed the effectiveness of the RTIEMS system in shortening the golden rescue time, thus remarkably enhancing the service quality of the emergency medical system [16]. Furthermore, Felzen et al. implemented a telemedicine system in seven ambulances to transfer vital signs with 12-lead ECG signal, image, and video stream through second and third-generation mobile networks. Altogether, 539 cases were supported with this system within a five-month study period, and the results verified the feasibility of the system [17].

In this regard, ASAYAR is a national mobile- based automation system for pre-hospital emergency care that was implemented in most pre-hospital emergency medical centers in Iran since 2018 to promote the quality of EMS, facilitate hospital selection, and transportation of emergency patients [7]. Given the wide and vast use of the ASAYAR in EMS operations in Iran, no study has yet evaluated its usability from the EMS team's point of view by employing a standard questionnaire. Thus, the purpose of this study was the usability evaluation of the ASAYAR among the EMS team to identify existing gaps.

MATERIAL AND METHODS

ASAYAR

ASAYAR is a national mobile-based automation system for pre-hospital emergency care that includes diagnostic and clinical consultation forms according to international standards, position detection, and tracking system based on GIS-based maps. The goal of the ASAYAR is to remove paper forms and record pre-hospital emergency activities electronically, to gain access to daily statistics and activities, to track and accurately record the dispatch time and ambulance arrived at the scene. This system was developed by the C# programming language and SQL Server 2012 database. The overall architecture is presented in Fig 1.

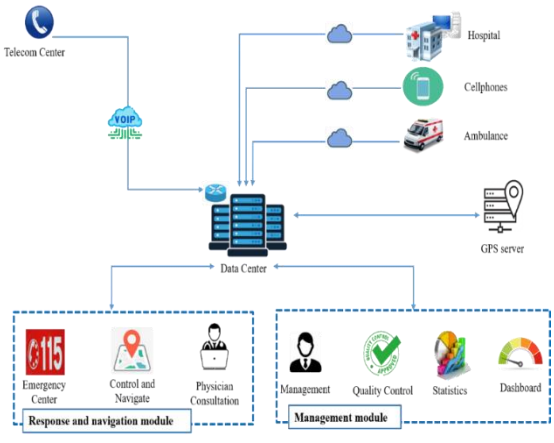

Fig 1: The overall architecture of the ASAYAR

To set up this automation system, all emergency centers were equipped with a web-based ASAYAR system for answering the phone call, as well as navigating and controlling the EMS team. Further, GPS devices were provided to the ambulance. All EMS teams were equipped smartphones with the ASAYAR automation system and internet connections to receive and store information in it. Fig 2 displays the flowchart of operation in the ASAYAR. The '115

emergency center' is the first part of the emergency response center. In this unit, the cause of the call is evaluated and in cases of requiring an ambulance, the request is delivered electronically to the 'dispatch and operation management unit'.

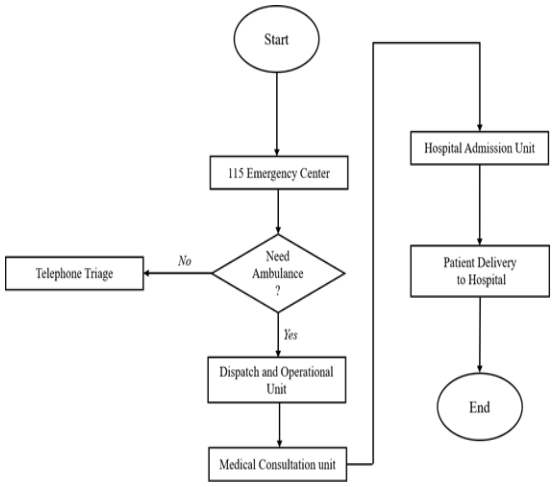

Fig 2: Flowchart of operation in ASAYAR pre-hospital medical service system

This unit is responsible for sending the most appropriate operational code in terms of type and geographical distance to the scene and real-time monitoring of the service delivery process until the end of the emergency team operation. The notification about the patient information such as an address, location, and main complaint is automatically sent to the nearest operating code smartphone.

Once the ambulance has arrived at the patient's bedside, all patient information is recorded via mobile phone by the operational code (samples are shown in Fig 3).

'Medical consultation' is the next unit that provides the most appropriate medical advice according to the patient's condition to the operation code. Eventually, the 'hospital admission unit' is responsible to determine the most appropriate medical center to dispatch the patient and delivery to the treatment unit. Quality control units, statistics, and management dashboards are other parts of this system to provide emergency medical services for managers in the form of an integrated system (samples are shown in Fig 4).

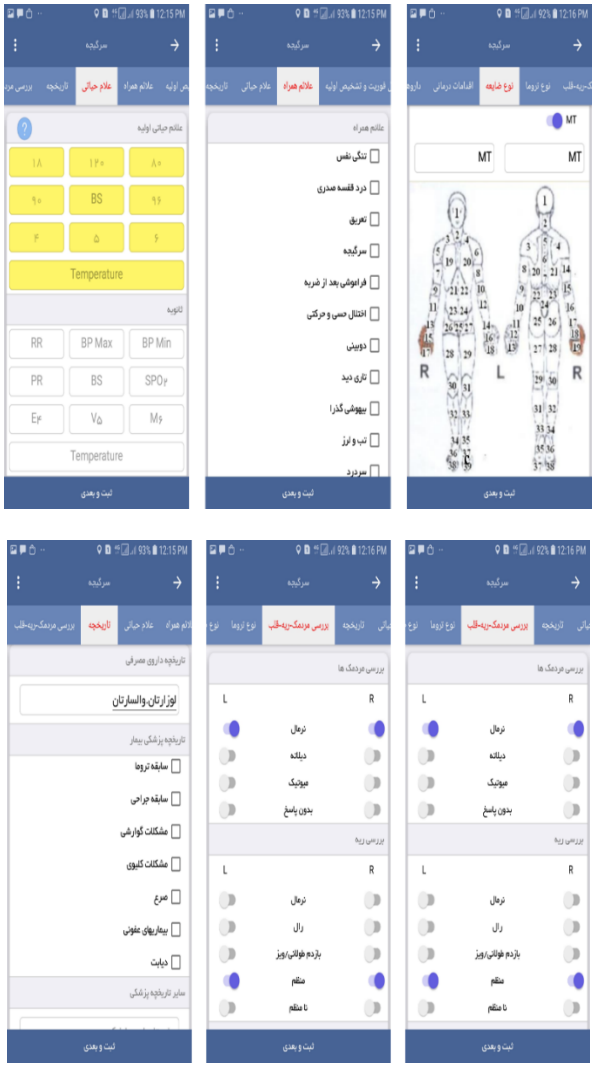

Fig 3: Screenshots of the ASAYAR on smartphones

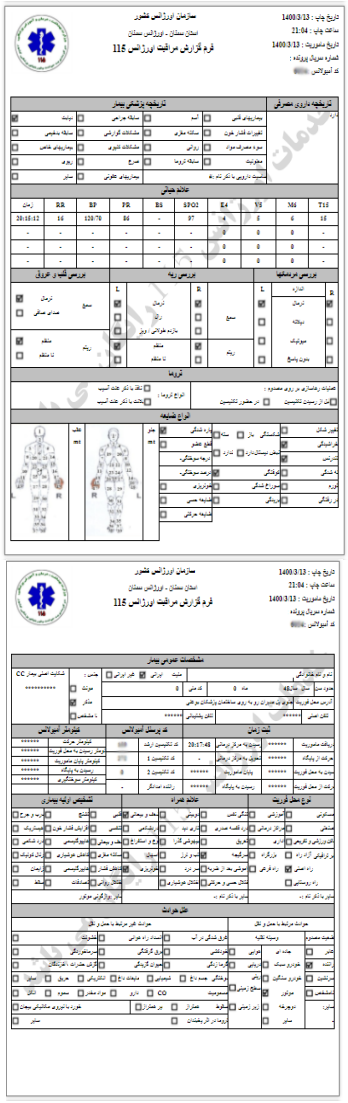

Fig 4: Screenshots of the ASAYAR on computer systems of EMS centers

Setting

This descriptive cross-sectional study was conducted in September 2022 in Iran. The study population consisted of all EMS team members, including employees, emergency centers managers, and chief managers as end-users of ASAYAR (N =220) in urban and interurban emergency centers affiliated to Semnan and Shahroud Universities of Medical Sciences, Iran. All of these users were male. At the time of the study, the ASAYAR was implemented on all of the 31 EMS centers in Semnan province. All the end-users had the same experience with the ASAYAR from its implementation date, and were initially trained on all parts of user interface.

After each participant agreement to take part and signed the informed consent, they were asked to complete demographic and Software Usability Measurement Inventory (SUMI) questionnaires. The demographic questionnaire included the information about age, work experience, education level, marital status, job title, computer skills, mobile skills and software skills.

Usability evaluation tool

The evaluation of the system was done using the Software Usability Measurement Inventory (SUMI) questionnaire [18] which measures users' experiences in five quality components including effect, efficiency, helpfulness, control, and learnability. The effect component shows the user's general emotional reaction to the software whose high rate indicates that the software is satisfactory and interesting for the user. The efficiency component refers to the relationship between the accuracy and completeness of users to achieve certain goals and developed resources to reach them. The helpfulness component is the degree of self-explanatory and adequacy of help documentation in software. The control component captures the feeling of user in controlling the software, which is the opposite of being controlled while using the software and finally, the learnability component is the speed and facility that make the user able to master the system or to learn how to use new features when needed.

These components provide an overall usability score based on which the user's overall understanding of system quality is provided. The SUMI Questionnaire contains 50 three-item (agree, undecided, and disagree) questions measuring five components of quality. Higher scores indicate the positive attitude of users in using the software [19]. This questionnaire has been translated into 20 different languages (including Persian) and its validity and reliability have been confirmed previously [19]. The validity and reliability of the Persian version has also been confirmed in another study [20]. Several studies have used the SUMI for evaluating the usability of information systems from the perspective of end-users [21-23].

In this study, data were collected using an online questionnaire. The link to the online questionnaire (http://survey.porsline.ir/s/VGYiAgi) was sent to 220 emergency team members. A reminder message was sent to users if the online questionnaire was not completed and answered within a specific time. A total of 188 subjects responded to the online questionnaire (85.45% response rate) which is acceptable according to the sample size in this study.

Statistical Analysis

For the quantitative variables, mean and standard deviation, and for qualitative variables, frequencies and percentages were reported. The Kolmogorov-Smirnov test with histogram were used to measure

the normality of data. In order to describe categorical variables such as demographic characteristics, frequency table was used. The mean, standard deviation, and quartile measures were calculated for each quality component, representing the users' attitude toward the functionalities of the ASAYAR. Also, multiple logistic regression models were used to explain the relationship between dependent binary variables and other variables. The SPSS-16 software was used to describe and analyze the data at significance level of 0.05.

Table 1: Participants' demographic characteristics

Characteristics	Groups	N (%)
Age category (years)	<35	97 (51.6)
	≥35	91(48.4)
Work experience (years)	<10	94 (50)
	≥10	94 (50)
Education	Less than bachelor	82 (43.6)
	Bachelor and higher	106 (56.4)
Marital status	Married	149 (79.3)
	Single	39 (20.7)
Job title	Staff	171 (90.9)
	Emergency center manager	9 (4.8)
	Chief of manager	8 (4.3)
Computer skills level	Poor	4 (2.12)
	Moderate	105 (55.85)
	Good	54 (28.72)
	Excellent	25 (13.29)
Software skills level	Poor	21 (11.17)
	Moderate	83 (44.14)
	Good	58 (30.85)
	Excellent	26 (13.82)
Mobile skills level	Poor	4 (2.12)
	Moderate	21 (11.17)
	Good	113 (60.1)
	Excellent	50 (26.59)

Ethical approval

Ethics approval was obtained from the Ethics Committee of Semnan University of Medical Sciences (IR.SEMUMS.REC.1398.198). A cover letter was submitted along with the online questionnaire, which described the purposes of the study and consent of the participants to take part in the research. The confidentiality of participants' responses was also assured.

RESULTS

One hundred eighty-eight male EMS team members participated in present study. The results showed that the mean age of participants was 34 ± 6.78 years and 51.6% of participants were less than 35 years old. Their mean work experience was 9.95 ± 5.84 years and 50% of participants had less than 10 years of work experience. In addition, 56.4% of the participants had a bachelor's degree or higher and 79.3% were married. Finally, 91% of participants were EMS team staff. In most of participants the computer and mobile skills were in moderate level (55.85% and 44.14%, respectively) and the software skills was good (60.1%) (Table 1).

Based on the total score of the SUMI questionnaire, 75% of the participants agreed with the usability of the ASAYAR (Fig 5).

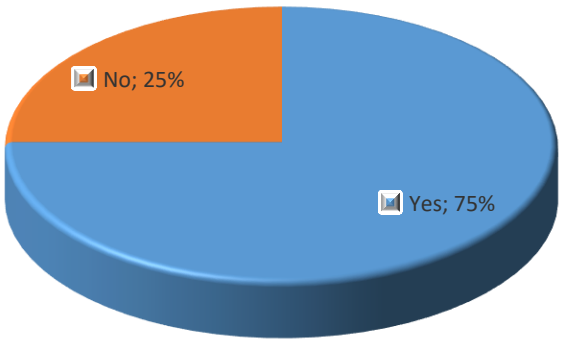

Fig 5: The percentage of the EMS team's agreements with the usability

The mean total usability score was 61.93 ± 15.37, where the highest mean score was related to the efficiency feature (67.19 ± 19.85) and the lowest mean score was related to the learnability feature (48.21 ±29.29) (Table 2).

Table 2: Measures of central tendency and dispersion statistics of standardized scores in each of the features

Features	Mean ±SD	Median	Quartile		
			25	50	75
Affect	61.03 ±19.94	62.5	43.7	62.5	75
Efficiency	67.19 ±15.85	63.6	54.5	63.6	77.2
Helpfulness	66.56 ±17.01	65	55	65	80
Control	65.59 ±13.92	63.6	54.5	63.6	77.2
Learnability	48.21±29.29	45	20	45	80

The findings in Table 3 indicated that there was an inverse and significant relationship between being a manager and the agreement with the usability. In fact, being an EMS center manager is associated with an increased chance of dissatisfaction (p=0.04, OR= -3.383, CI 95% = 0.389-29549) (Table 3).

Table 3: Multiple regression analysis of the relationship between participants' demographic characteristics and their agreement with the usability

Characteristics	P-value	OR	95% CI for EXP(B)	
			Lower	Upper
Age	0.95	0.99	0.90	1.09
Work experience	0.72	0.97	0.86	1.10
Education	0.27	1.42	0.75	2.69
Job title (staff)	0.06			
Job title (emergency center manager)	0.04	-3.38	0.38	29.45
Job title (chief of manager)	0.85	0.20	0.04	0.98

DISCUSSION

The purpose of present study was the usability evaluation of the ASAYAR among the EMS team. In this study, although the total mean score showed that the participants agreed that the ASAYAR had good usability (mean=61.93±15.37), this agreement only existed among 75% of the participants. In other words, a small number of participants had difficulty in using the system. Previous studies have shown that the adoption of health automation system and information technology, especially in emergency environments, increases the effectiveness and quality of medical care by accelerating and simplifying the clinical workflow and reducing human error [24-26]. Rangraz Jeddi et al. evaluated the usability of a comprehensive national health information system (HIS) from the perspective of 250 users by SUMI questionnaire. The mean scores of all usability components were significantly low (42.1±13.5). They found that the national health information system had low usability [27]. The results of this study indicated different scores of usability in all quality components for the evaluated automation system. The results of the system effect revealed that the participants believed that the system was on average (61.03±19.94) satisfactory and interesting. The results indicated that this type of pre-hospital EMS automation system how much can be acceptable to the EMS team by providing data such as patient identity information, disease severity, triage information, patient transfer status, and tracking. Ientile et al. evaluated a pre-hospital EMS information system in Lazio region in Italy. They found that the information system could product ad hoc reports and develop specific indicators. These information system features allowed the pre-hospital emergency care team to identify and analyze critical processes to take any helpful actions and to monitor the effectiveness of the actions [4].

Time, accuracy, and completeness are indicators of effectiveness [28]. The findings of the system efficiency indicated that the study subjects believed that the system helped them on average (67.19 ±15.85) to complete their tasks properly and achieve the goals of the EMS. In other words, this result suggests a system for pre-hospital emergency care how much is flexible and can facilitate the task of users. Kim et al. evaluated the usability of an emergency department information system by expert and novice nurses. They found that Nurses could perform between 60 and 62% of their tasks without clinical errors by the information system [29].

Given that pre-hospital EMS teams often have to make quick and vital decisions, it is critical to collect data at the scene to decide on the patient's condition and determine the type of healthcare center [30]. The score of the helpfulness of the system revealed that the EMS team believed that the system was on average self-explanatory (66.56 ±17.01) and allowed them to perform their tasks quickly. This finding indicates that how much a national mobile- based automation system for pre-hospital emergency care enhances the quality of EMS, its accuracy, and helps to make decisions based on better evidence. The findings of Kim et al' study confirm the results of our study. They indicated that fifth-generation mobile technology can simplify pre-hospital emergency care, increase the effectiveness and timeliness of EMS, and facilitate the provision of appropriate patient care; as a result, it may improve the patient's conditions [31].

The score of "Control" functionality of the system indicated that this functionality could on average control the tasks of the EMS team (65.59 ±13.92). The results show ASAYAR both helps the EMS team adopt the best strategy and controls emergency operations from the scene of the accident to the transfer of the patient to a medical center. This study indicated that capacity and potential of pre-hospital emergency care could be properly used by "Control" functionality of ASAYAR.

The results of this study also showed that the score of the learnability was significantly lower than that of other functionalities of the system. This functionality generally enabled (48.21±29.29) the participants to master the ASAYAR, or to learn how to use its new features. In Reis et al.'s study, 84 health care providers participated in an online SUMI survey evaluating the usability as well as medical and managerial effect of data exchange in a virtual health record. That study showed that clinical professionals had the lowest rating of the data exchange. Clinicians reported their concerns and need for further learning and support [22].

Based on the results, being an emergency center manager significantly (OR= -3.383, P=0.047) reduced the chances of agreement with the usability of the ASAYAR by more than three times. Maybe they confront with its implementation problems closely.

These findings indicate that ASAYAR has not met the expectations of the managers in any way. Hence, it is expected that by redesigning ASAYAR, the information needs of all users at the organization level will be met.

Implications

First, this study is useful for the mobile- based automation system designers. The results enable them to design a user-friendly automation system that can increase the effect and performance of the team and enhancing the quality of the pre-hospital emergency care.

Second, this study findings have implications for EMS centers that intend to implement ASAYAR These centers will be able to better understand whether a ASAYAR will adequately support the EMS team.

Third, this study encourages health policymakers to expand EMS teams' contributions especially EMS managers regarding the national automation systems reforms. When users' voices are heard, it not only helps improve these technologies but also creates a sense of responsibility toward the meaningful use of this technology and ultimately improve the quality of pre-hospital emergency care for injured patients.

Finally, this study presents a chance for researchers to evaluate challenges and facilitators of EMS teams' use of ASAYAR. These challenges and facilitators may vary at different points in time after the implementation of these systems.

Strengths, Limitations, and Future Research

First, although this evaluation was done in two areas of Iran, the results cannot be generalized to all pre-hospital emergency care teams in the country. Secondly, the effectiveness and satisfaction were not set in the questionnaire under a definite title, while being suggested by ISO as components of usability. The last limitation was related to fairly large number of questions and the workload of the EMS team that made it difficult to complete the questionnaire. To resolve this limitation, the researchers explained the importance of the study results to users to encourage them to complete the questionnaire. Despite the efforts of the researchers, in the first stage, some users did not complete the questionnaire and the researchers followed it in the second stage. To obtain important findings, subsequent studies may be performed with more users and using different usability evaluation tools.

CONCLUSION

It is concluded that a national mobile- based automation system for pre-hospital emergency care can enhance the effectiveness of pre-hospital emergency care. This study showed that the widespread use of a technology in a country is not a sign of its high usability. Thus, functionalities of ASAYAR should further be improved not only to support the implementation and meaningful use of this technology but also to reduce the preparation time for treating the injured patients in critical cases and significantly increase the quality of the EMS. At the end, to improve the different function of these systems, it is suggested to participate various clinical experts include prehospital emergency care team in all stages of designing and developing these systems.

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AUTHOR'S CONTRIBUTION

All authors contributed to the literature review, design, data collection and analysis, drafting the manuscript, read and approved the final manuscript.

CONFLICTS OF INTEREST

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

FINANCIAL DISCLOSURE

No financial interests related to the material of this manuscript have been declared.

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