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MEDICAL INFORMATION SYSTEM FOR EMERGENCY SERVICE: COMPARISON OF TABLET PC AND WAP DEVICES

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ABSTRACT
Mobile technologies help us to improve data entry and query mechanisms effectively. Medical information systems have not taken benefits from mobile advantages enough for electronic health records (EHRs). Data gathering processes can be provided by high qualified and user oriented developed graphical user interfaces especially in mobile devices. In this study, two software prototypes are developed for the emergency service to be operated on Tablet PCs and wireless application protocol (WAP) based cellular phones for taken benefits of the mobile technologies, which are tested in Acibadem Hospital in Istanbul, Turkey. The applications have the same menu structure with high oriented GUI designs. Both prototypes are designed by considering user centered development methodology and usability evaluation activities with human computer interaction (HCI) techniques such as cognitive walkthrough. In this study, there is a comparison between these two prototypes. The benefits and shortcomings of the both systems are concluded.
Keywords: Electronic Health Records, Mobile Healthcare Information Systems, Wireless Application Protocol, Tablet PCs, Usability Engineering, Human Computer Interaction

1. INTRODUCTION
Electronic healthcare records (EHRs) can be obtained by accurate data entry systems to support the healthcare information systems. Implementation of effective user interfaces can enhance the reliability of data [1]. Adopting mobile data entry forms to keep patient records provides more secure, accurate and easily accessible way [2]. Development of an effective, portable and secure system by using wireless technologies, and mobile workflow processes are the important part of the foundation for improved healthcare delivery system.

In real life, emergency services of every hospital should be rapid enough to provide necessary service for the coming patients. They should be developed a modern and faultless healthcare service system, which makes possible to gain in time to increase the quality of service with help of the stable healthcare information systems. A mobile healthcare information system must be implemented to obtain long-term solutions [3].

Effective and usable user interfaces must be intended with its focus on usability engineering. Establishment of what and how users understand graphical user interfaces can be handled by using human factors engineering(HFE) techniques for healthcare information systems [6,7]. Instead of using such a system for the given function in desktop computers, mobile devices as tablet PCs or WAP supported cellular phones provide elasticity and portability for the clinicians to assist treating patients [8]. On the other hand, it is fact that medical doctors may have some difficulties to use mobile devices more than desktop computers. An application has to be developed with special user interfaces created according to the user-centered development methodology to run on Tablet PCs and WAP supported cellular phones. Usable software interfaces enhance reliable and correct data entry rate by mobile and portable devices. Interfaces are established by considering the inputs taken from the healthcare staff of the hospital and the prepared, printed forms used before are included for the system development.

Wireless application protocol (WAP) is one of the most well known technical standards for mobile devices which is founded by WAP Forum in 1997 by the involves of Nokia, Ericsson, Motorola and Unwired Planet [4,5]. Additionally, wireless application protocol is a common feature exposed for mobile communication devices. WAP supported devices have some usability handicaps when compare them with tablet PCs. Tablet PCs have some key advantages such as [10];

- Common operating systems compatibility like desktop PCs,
- The A4 sized display with virtual keyboard.

The most significant benefits of using mobile devices are mobility and low cost [9]. Yet, preferring a computer rather than a phone for wireless protocol would be more powerful because of the memory capacity and resources. From this viewpoint, we are looking for usability advantages between WAP enabled devices with tablet pcs.
In this study, two different prototypes are developed for monitoring conditions of the patients who care in emergency service of Acibadem Hospital in Istanbul. Mobile emergency service software development cycle includes the requirements, design and evaluation analysis based on user centered development methodology.

2. METHODOLOGY

2.1 The Aim of the Study

The aim of this paper is getting the success rate of efficient use in terms of data entry time for end users in mobile healthcare system. Additionally, suitable interfaces are designed for both mobile devices and usability evaluation is completed from the point of healthcare staff in the emergency service. Prototypes are developed by including the analysis of how much of service processes can be applied to electronic environment. The role of interface components observed while designing the interfaces related with visual programming language. Finally, the obtained critics from creating forms in requirement analysis stage are gathered from system users.

2.2. User Centered Development Methodology

User centered development is an approach that based on feedbacks of the system users who will use the software system. The processes relate with analysis, design and development of a product in a spiral development life cycle. There is an international standard that is the basis for many user centered development methodologies. It defines a general process for including human-centered activities throughout a development life-cycle [11]. User centered development methodology is used from analysis phase till usability analysis, to evaluate users' reactions and understanding about the prototyping of both systems [12].

Table 1. User Centered Development Methodology

1. Analysis Activities	2. Design Activities
a. Specification of the Context of use	a. Develop Product Concept
i. User Analysis	b. Prototyping
ii.Task Analysis	c. Interaction Design
b. Usability Specification	3. Evaluation Activities
	a. Usability Analysis

2.3. User and Task Analysis

There are two main roles; nurses to enter new data for the patients and physicians to update any required data to monitor the conditions about any patients. An identification number or protocol number is assigned after registration for each patient. These two roles have different task sequences; for this reason, the menu systems are designed according to the printed emergency service forms for both prototypes. The task sequence of the nurses for the system is given in Table2.
Table 2. Nurse Task Sequence

Task code	Task detail	Task Importance	Task code	Task detail	Task Importance
T1	Patient Identity	100%	T13	Mood	5%
T2	Triage	100%	T14	Still used medicine	100%
T3	Translator	2%	T15	Family History	5%
T4	Arrival complaints	100%	T16	Contact	12%
T5	Judicial events	10%	T17	Arrival vital symptoms	100%
T6	Allergy	100%	T18	Pain	100%
T7	Previous diseases	100%	T19	Required inspections	87%
T8	Previous surgeries	100%	T20	Requests and applications	57%
T9	Addictions	100%	T21	Vital symptom observations	100%
T10	Functional efficiency	65%	T22	Observations of nurse	52%
T11	Nutrition	%3	T23	Discharged from hospital	100%
T12	Religious belief	0%			

In these prototypes the mostly used task sequence is S1={T1, T2, T4, T5, T6, T7, T8, T9, T14, T17, T18, T21, T23} for the nurses. Each S1 task sequence starts from T1 for the physicians to monitor the searched patient, and then the system automatically passes to the next task. Also physicians have a different task sequence for their related works.

2.4. Cognitive Walkthrough

Usability can be defined as the ease of use and acceptability of a system for a particular class of users carrying out specific tasks in a specific environment. It depends on the end user's experience and effort with the software product in the parallel of the combination of the all factors such as learnability, satisfaction, effectiveness, usefulness of the product and efficiency.
Cognitive walkthrough is a technique to evaluate the design of a user interface from the point of end-users since initial design of interface to employment phase. The primary target of implementing cognitive walkthrough methodology is to follow up the process for the users to inspect the simplest way by creating an action sequence tree including defined tasks that are broken into the sub task hierarchy [11]. Cognitive walkthroughs are useful in getting interface problems at an early stage, and works particularly well together with a user centered design approach and the development of user interfaces.

The developed software prototypes have been tested in the cognitive walkthrough evaluation methodology, according to the items listed below.

1. Prototyping of the both prototypes are prepared for interface usability testing,
2. A description for tasks is listed for nurses,
3. A scenario is prepared for the needed actions,
4. Experienced and novice users are determined.

3. TEST RESULTS

The data related with the user performance measurement when interacting with both prototypes and the evaluation of the user reactions. Additionally, users' mental efforts are measured and operational complexities are analyzed. Last step of the user centered development methodology is usability analysis is also performed in the evaluation phase.

Nurses are asked to select the related form from the menu and enter the related data according to the printed version of the emergency service form according to the scenario. Usability evaluations implemented with the second and third evaluation tests. The correctness ratio of the entered data in a unit time is 100% for both prototypes when forms that include only selection typed input elements. Information entry forms filled with 10-20% errors by virtual keyboard. Even though two nurses are left handed, are among the users that finished data entry in the shortest time period. Also data entry forms filled with 12-22% error by cellular phones.

Developed prototypes are tested with selected six different nurses from the emergency service staff of Acibadem Hospital in Istanbul, Turkey. According to Table 3, a test is completed over six nurses and each has different familiarities over computer usage. The average data entry ratio in a unit time of

these selected six nurses to fill forms in terms of seconds in Tablet PC application and WAP application are given in detail.

Table 3. The average information entry ratio of nurses to fill forms in the second tests

	Nurse1		Nurse 2		Nurse 3		Nurse 4		Nurse 5		Nurse 6		Average Time (sec.)	
	TPC	WAP	TPC	WAP	TPC	WAP	TPC	WAP	TPC	WAP	TPC	WAP		
System Entry Form	5	8	30	25	18	30	5	5	5	5	5	10	11.33	13.6
Identification Form	106	120	100	110	90	130	70	90	90	100	70	70	87.67	103.3
Arrival Complaint Form	30	25	10	20	15	25	10	15	15	30	15	20	15.83	22.5
Previous Diseases Form	20	30	15	15	15	10	10	20	10	25	5	15	12.5	19.2
Addictions Form	30	40	35	50	25	35	35	30	40	40	30	55	32.5	41.6
Still Used Medicine Form	55	60	50	55	50	75	35	40	50	60	40	40	46.67	55
Family History Information Form	5	10	15	10	5	15	25	30	5	5	15	10	11.67	16
Arrival Vital Symptoms Form	60	45	33	40	45	60	40	45	50	50	30	45	43	47.5
Pain Location Form	25	35	60	45	90	70	70	85	60	70	40	65	57.5	61.6
Pain Kind Form	10	15	5	10	5	5	15	15	5	10	10	5	8.33	10
Required Inspections Form	25	30	15	15	20	35	15	20	15	15	20	30	18.33	24.1
Requests and Applications Form	25	30	15	15	15	20	15	15	15	30	15	10	16.67	20
Discharge from Hospital Form	15	10	10	5	10	15	10	10	15	10	10	5	11.67	11
Success Ratios (%)	74.21	72.45	77.61	78.23	75.68	77.22	85.92	90.87	81.33	79.45	100	99	82.46	81.49

4. CONCLUSION

In this study, two different mobile healthcare systems are developed for the same purpose that is for Table PCs and wireless application protocol (WAP) supported cellular phones to evaluate the usability of these prototypes. The ease of learnability is a part of usability, which has a significant role of operating the product in high success ratio. Furthermore, getting feedback from the healthcare staff, implementing human computer interaction techniques with cognitive walkthrough increased the success ratio of the product in terms of usability. The virtual keyboard over the Tablet PC provided more benefits than cellular phones and because of that the completion time of six selected nurses for the Tablet PC is shorter than the other prototype.

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