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PAPER

Usability Evaluation of Tablet-Based Electronic Medical Record Interface in Supporting Elderly Medical Doctors

Hasanin Mohammed Salman(✉), Firas Husham Almukhtar

Department of Information Technology, Catholic University in Erbil, Kurdistan Region, Iraq

hasanin.salman@cue.edu.krd

ABSTRACT

Recently, tablet-based devices have become significantly more utilized platforms for electronic medical record (EMR) systems. EMR is the digital counterpart of the medical doctor's office paper charts. EMR systems contain the medical and treatment histories of the patients in a unified practice. Nevertheless, statistics indicate that a considerable percentage of medical doctors are elderly, aged 60 and above. As using mobile handheld devices (including tablets) poses a well-recognized usability challenge for elderly users, the user interface (UI) usability of tablet-based EMR systems must be thoroughly assessed, considering the needs of elderly medical doctors. Accordingly, our objective is to address this need. Three expert evaluators implemented the heuristic evaluation (HE) approach to evaluate the UI usability of a commercial EMR system that is a tablet-based platform. Applying the HE approach helped identify usability problems that elderly medical doctors might encounter when utilizing a tablet-based EMR UI. In total, eight usability problems contributed to the seven heuristic violations discovered.

KEYWORDS

usability evaluation, tablet device, electronic medical record (EMR), user interface (UI), elderly, medical doctors

1 INTRODUCTION

Medical records are regarded as a requirement for the efficient storage, distribution, and use of patient data in healthcare institutions. Medical records contain information about the patient's treatment history and relevant experiences in patient care. A written record of a patient's medical history is provided when a medical record is updated. This medical history creates a database to help specialists decide and plan future medication regimens. Typically, documentation in the medical field has been handwritten by specialists and filed into paper medical records (PMRs). The shortcomings of PMRs are apparent; they can be unreadable, incomplete, and poorly organized. These flaws make healthcare quality assurance difficult [1] [2].

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To avoid the shortcomings of PMRs, most developed countries have deployed electronic medical records (EMRs) [3–5]. EMR is the digital counterpart of the paper charts in the clinician's office; they contain the medical and treatment histories of the patients in one practice [6]. Once deployed, EMRs can benefit both medical practices and patients.

The use of EMR in hospitals has numerous benefits, including the automation of clinical and administrative processes, the facilitation and acceleration of information exchange between hospital departments, the generation of accurate and timely reports, the improvement of healthcare providers' performance, increased patient satisfaction, and cost savings [7] [8].

The adoption of electronic medical systems has made health data retrieval and manipulation easier, but it has also generated new dimensions of challenges. Lack of usability among these challenges is one of the fundamental causes of the failure of 30% of EMR systems [3] [9]. Usability is a quality criterion for information systems that is assessed by evaluating their UI. Problems with the UI can lead to increased user mistakes, lower user satisfaction, and decreased productivity and efficiency levels, and thus are a significant obstacle to adopting information systems [8] [10].

Recently, mobile handheld technologies, including tablets, have become far more accessible in clinical care settings in both urban and rural healthcare institutions [11]. Appliances such as smartphones and tablets provide up-to-date data as a reference for healthcare providers [12]. According to a relevant survey, more than half of medical doctors believe that using a tablet computer improves the time spent dealing with patients, provider efficiency, the process of treatment, and satisfaction with EMR systems [13]. But the statistics indicate that a considerable percentage of medical doctors are elderly (i.e., 60 years of age and above) [14]. There is a problem with using mobile handheld devices, including tablets, for the elderly; using these appliances is a well-recognized usability challenge for elderly users [15–18]. Usability has been identified as the most significant barrier to the widespread adoption of EMRs since it has a strong relationship with clinical productivity, error rate, and user satisfaction [3] [19]. Therefore, the UI usability of tablet-based EMR systems must be regularly assessed, considering the needs of elderly medical doctors.

Accordingly, this study's main objective is to conduct a usability evaluation of an EMR system interface that is compatible with tablet computer platforms for supporting elderly medical doctors. The scope of the study is to consider investigating an EMR system commonly used by various clinics and hospitals.

The remainder of this paper is organized as follows. In the next section, the study background is demonstrated. Section 3 describes the method applied to conduct this study. Section 4 presents the results and discussion. Finally, conclusions are drawn in Section 5.

2 BACKGROUND

2.1 Usability of EMR systems

Usability is typically defined in terms of how simple UIs are to use. This concept states that the lack of usability problems determines whether usability is present (and vice versa) [20]. EMR systems have several usability problems, many of which are brought on by their complicated UIs [21] [22]. Some medical doctors (and medical staff in general) still prefer to utilize their paper forms rather than electronic systems because many electronic medical applications have failed because of their UIs, which are challenging to learn and use [21] [22].

Numerous studies have evaluated the usability of different EMR systems, and they frequently found major usability problems and showed that these problems had a detrimental impact on how users interacted with the systems [8] [21] [23]. The usability of an electronic medication administration record system was examined, and 60 usability problems were found, including a sizable number of major and catastrophic issues. According to reports, these issues can reduce users' effectiveness, efficiency, and satisfaction [24]. Another study assessed the usability of a laboratory and radiology module's UI for a healthcare information system [25]. The findings of this study [25] revealed that, although widely used in many institutions, the system's UI had a substantial number of problems, many of which were major and catastrophic, which may delay medical doctors' access to laboratory tests and radiology data. A study analyzing the data entry module of an electronic patient record system revealed that 40% of expert navigational activities deviated from the predetermined system actions, primarily due to misalignment between system design and user expectations [23].

Regardless of the benefits of the reviewed studies, there is limited attention given to evaluating the usability of the interfaces of table-based EMR systems from the perspective of elderly medical doctors. Accordingly, this study aims to address this gap.

2.2 Heuristic evaluation of usability

Heuristic evaluation is a common usability evaluation technique that is most frequently employed in the field of human-computer interaction (HCI) [26]. HE has numerous advantages over other usability evaluation methods: it is inexpensive, fast [27–29], and its implementation is straightforward [27]. Around 75% of usability problems may be found with the help of only three experts (the number of experts could be expanded to five) [27] [28] [30]. Additionally, HE can be carried out by individuals who possess either usability competence or domain knowledge, or both [27] [28] [30].

To implement the HE, experts assess a UI to determine if it complies with a set of design principles (heuristics) [28]. When an expert detects a usability problem, one (or more) of the heuristics listed is considered violated [28]. To identify potential usability problems users can encounter when engaging with the interface, experts apply HE to the UI [29]. The HE study's final output is a comprehensive report that details the usability problems found and the related recommendations for fixes [28]. Jakob Nielsen suggested ten heuristics that can be used to evaluate the usability of most user UIs independent of the platform (e.g., desktop-based and tablet-based) [28] [31]. Table 1 illustrates Nielsen's ten heuristics along with their definitions [31].

Table 1. Nielsen's ten heuristics [31]

	Heuristics	Definition
1	Visibility of system status	"The design should always keep users informed about what is going on, through appropriate feedback within a reasonable amount of time."
2	Match between system and the real world	"The design should speak the users' language. Use words, phrases, and concepts familiar to the user, rather than internal jargon. Follow real-world conventions, making information appear in a natural and logical order."
3	User control and freedom	"Users often perform actions by mistake. They need a clearly marked 'emergency exit' to leave the unwanted action without having to go through an extended process."
4	Consistency and standards	"Users should not have to wonder whether different words, situations, or actions mean the same thing. Follow platform and industry conventions."

(Continued)

Table 1. Nielsen's ten heuristics [31] *(Continued)*

	Heuristics	Definition
5	Error prevention	"Good error messages are important, but the best designs carefully prevent problems from occurring in the first place. Either eliminate error-prone conditions, or check for them and present users with a confirmation option before they commit to the action."
6	Recognition rather than recall	"Minimize the user's memory load by making elements, actions, and options visible. The user should not have to remember information from one part of the interface to another. Information required to use the design (e.g., field labels or menu items) should be visible or easily retrievable when needed."
7	Flexibility and efficiency of use	"Shortcuts—hidden from novice users—may speed up the interaction for the expert user so that the design can cater to both inexperienced and experienced users. Allow users to tailor frequent actions."
8	Aesthetic and minimalist design	"Interfaces should not contain information that is irrelevant or rarely needed. Every extra unit of information in an interface competes with the relevant units of information and diminishes their relative visibility."
9	Help users recognize, diagnose, and recover from errors	"Error messages should be expressed in plain language (no error codes), precisely indicate the problem, and constructively suggest a solution."
10	Help and documentation	"It's best if the system doesn't need any additional explanation. However, it may be necessary to provide documentation to help users understand how to complete their tasks."

Not all usability issues are addressed equally; some may be aesthetic design flaws, while others may impact how well the system performs its primary functions [28] [32]. Using a five-level structure is an effective way to classify the severity of usability difficulties [28] [32]: 0: not a usability problem, 1: cosmetic problem, 2: minor usability problem, 3: major usability problem, and 4: usability catastrophe.

3 METHOD

3.1 Procedure

Considering this study objective and the advantages of the HE approach (as demonstrated in Sections 1 and 2.2, respectively), the HE is the adopted approach to conduct this study.

This study investigated an EMR system that is a tablet-based platform (in addition to its compatibility with a desktop platform). The investigated EMR system is intended to be used by a group of local clinics and hospitals. The system aims to store, manage, and retrieve clinical and medical data corresponding to patients and ultimately replace traditional paper-based medical records. Our study objective is to evaluate the UI usability of this tablet-based EMR system for supporting elderly medical doctors. Thereby identifying the shortcomings of the current EMR system and suggesting alternative design solutions for the future version.

Our participating evaluators work in clinics and hospitals employing the aforementioned EMR system. Furthermore, to avoid any bias in the evaluation results, the system's default theme (and overall settings) have been examined. Figure 1 illustrates the main screen of the evaluated EMR system. In Figure 1, red boxes hide UI sections that present patients' confidential data.

According to [28], HE has three stages: a briefing session, an evaluation period, and a debriefing session. The HE procedure in this study is comprised of these three stages.

The following points summarize the activities that each evaluator should follow while inspecting systems UI:

1. Briefing session: The experimenter (observer) gives an overview of the study's background, objective, heuristics used, apparatus, and target users to each evaluator. The limits of the elderly users were thoroughly explained to each evaluator by the experimenter. Vision, hearing, cognitive, and motor function issues are just a few age-related restrictions that may make it difficult for elderly people to use mobile-based systems [17].

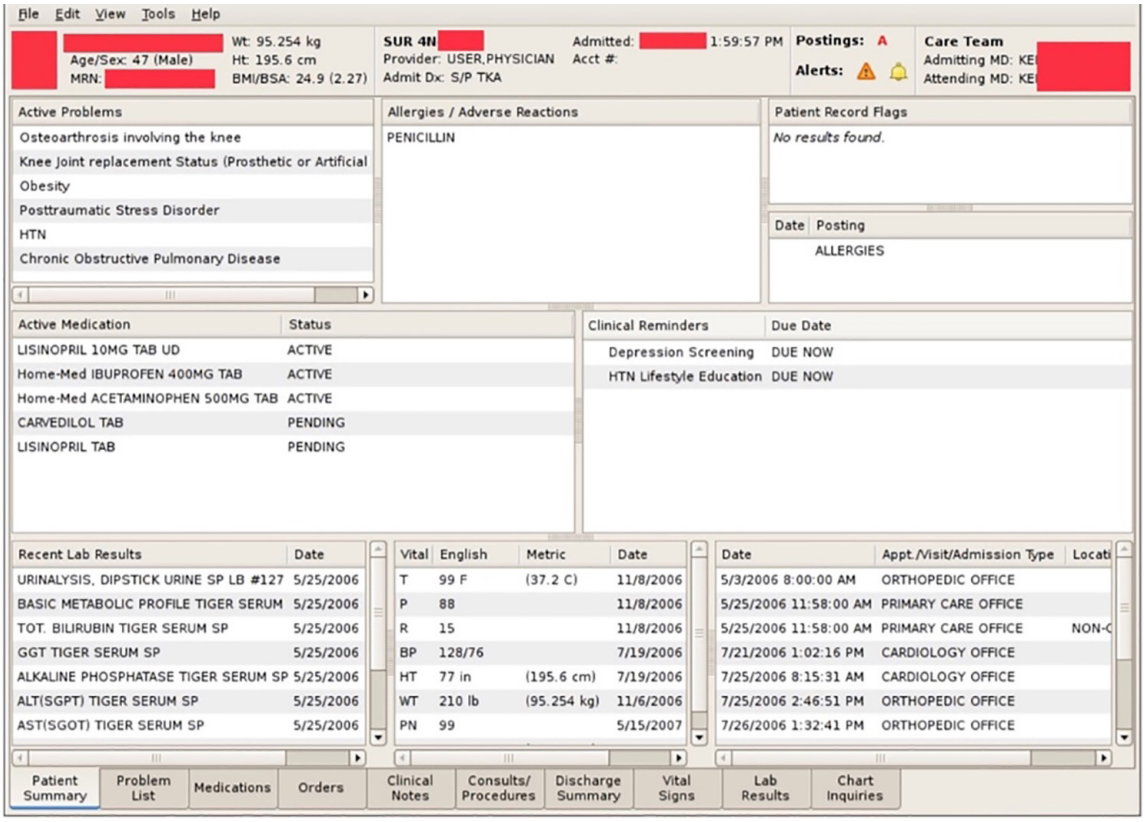

Fig. 1. EMR main screen

2. Evaluation period: The evaluator reviews a list of the 10 Jakob Nielsen heuristics [31] and their descriptions. The evaluator then carries out a set of tasks on the tablet-based EMR system chosen for the evaluation. The evaluator assumes the role of the user of the system. When an evaluator encounters a usability problem, they note it on a tabular form that displays the pertinent information (the place of problem occurrence, the heuristic that it violates, and a suggested solution). After completing the evaluation's chosen tasks on the EMR system, the evaluator conducts additional system inspections. (For instance, attempt to develop scenarios for error conditions to test system responsiveness.) The experimenter then compiles the evaluation findings of all three evaluators, consolidates the usability problems, and removes duplicate issues. The final result of this phase will be the creation of a master sheet that summarizes the evaluation findings.

3. Debriefing session: At this stage, each evaluator was provided with the master sheet containing all the discovered usability problems, including those found by the other two evaluators. They were then asked to rank the severity of each issue using the Nielsen scale [28] and [32], after which an average was calculated.

3.2 Evaluators

The three evaluators in this study are medical doctors who used EMR systems to coordinate different clinical tasks. Three evaluators can detect a high percentage of potential usability problems [27] [28] [30]. To better consider the needs of elderly clinicians, all the evaluators selected for this study are elderly (age 60 and above). Additionally, evaluators can help with the usability evaluation of tablet-based EMR systems thanks to their relevant knowledge of practicing HE in the medical field. By participating in HCI workshops, where conducting HE for medical information systems was one of the workshop activities, evaluators could employ this usability knowledge to contribute to this study. Table 2 shows the evaluators' demographic profiles.

Table 2. Evaluations' profiles

Evaluator	Gender	Age	Profession	Experience		
				Medical Field (in Years)	Conducting HE	
					Years	Evaluated Systems
1	Female	63	Dermatologists	18	6	More than 9
2	Male	60	Ophthalmologists	15	3	5 to 9
3	Male	61	Cardiologists	16	4	1 to 4

4 RESULTS AND DISCUSSION

4.1 Results

The expert evaluators examined the interface of the tested EMR system for compliance with Nielson's ten heuristics. The evaluation results show that identification of eight usability problems and seven heuristic violations. The distribution of usability problems across Nielson's heuristics is illustrated in Figure 2. As depicted in Figure 2, two usability problems correspond to the flexibility heuristics (i.e., flexibility and efficiency of use) with severity ratings of 2.67 and 3, respectively. Other heuristics either have one corresponding problem or none detected.

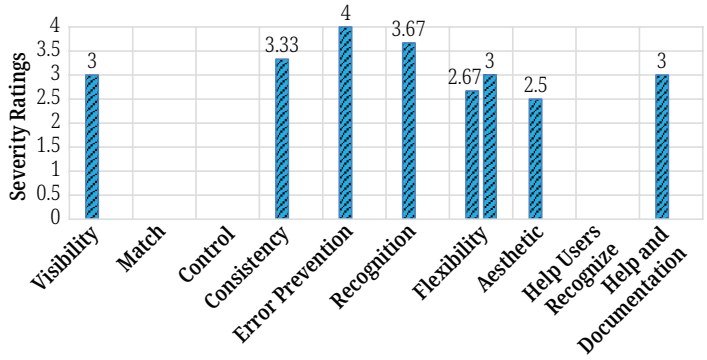

Fig. 2. Spread of usability problems into heuristics

The evaluators also estimated the severity of each usability problem during the debriefing session, and then the mean was calculated. Calculating mean severity involves numbering by the following formula: the sum of the severity ratings provided by each evaluator divided by the number of evaluators (i.e., 3). The detected usability problems were either catastrophic or major. More in detail, there were two catastrophic problems (severity rating > = 3.5) and six major problems (3.5 > severity rating > = 2.5), as illustrated in Figure 2.

The description of the usability problems, relevant violated heuristic(s), mean severity rating, and suggested solutions are all illustrated in Table 3.

Table 3. Usability problems description

	Usability Problem Description	Heuristic Violated	Severity Rating	Solution
1	Using identical text labels for buttons that perform contrasting functions. Example: "create" is used as a label for two different buttons, one button that initiates creating a new patient record function and another that starts creating a request for technical support.	Consistency and standards.	3.33	• Use a unique text label for each button. • Apply those labels consistently over the EMR system.
2	There is no confirmation message for certain destructive functions. For example: when a user accidentally taps a delete button, a patient's record will be deleted immediately and permanently.	Error prevention.	4	Provide a prompt, clear confirmation message detailing each destructive function's consequences. Support each message with a cancel option.
3	There is no immediately apparent feedback given after some actions are taken. Example: When a user taps the submit button to send a patient record to the system, no feedback is given to let the user knows the record has been sent successfully.	Visibility of system status.	3	Design a system UI that provides instant obvious feedback for user's action.
4	Overloading interface with information that is irrelevant to the user's current task.	Aesthetic and minimalist design.	2.5	• Present the interface with information pertinent to the current task. • Use grouping for less important information, and avoid information wholly unrelated to the user's current task.
5	Notifications and alerts are scattered between various interfaces of the EMR system.	Recognition rather than recall.	3.67	Provide a control widget that gathers and arranges the received notifications and alerts to help the user handle them.
6	Lack of instructions that give the user guidance to help users complete challenging tasks that involve several steps.	Help and documentation.	3	• Give clear instructions focused on the user's current task and indicate the required steps to take. • Add tooltips to the UI when necessary, such as when a particular gesture is needed to complete a particular task.
7	Challenging gestures are required to perform certain functions that lower user efficiency. Example: moving the patient record file from one interface/screen to another only using the "drag and drop" gesture.	Flexibility and efficiency of use.	2.67	Avoid or limit the use of complicated gestures such as "drag and drop". Instead, make "tap" the primary system-interaction gesture.
8	One-by-one selection is inefficient. Adding values one at a time is also wasteful.	Flexibility and efficiency of use.	3	Use UI elements that allow for a selection/checking of multiple items in one shot. For instance, employ drop-down menus and checkboxes.

4.2 Discussion

The expert evaluators agreed that the evaluated tablet-based EMR system provides most of the functionalities that medical doctors and staff require to record the various medical records. However, the HE results show that the EMR system interface does not fully adhere to Nielsen's heuristics in multiple facets. In total, eight usability problems contributed to the seven heuristic violations detected. The heuristic most commonly violated was "Flexibility and efficiency of use" (2 counts). "Consistency and standards," "Error prevention," "Visibility of system status," "Aesthetic and minimalist design," "Recognition rather than recall," and "Help and documentation" heuristics were found to be violated once. The frequencies of the heuristics violated can vary from one EMR system to another, as seen in the previous relevant works [8] [33]. This variation could be attributed to the UI design of each system and to what extent the UI design follows the applied heuristics. Though the expert evaluators did not discover any usability problems related to the "Match between system and the real world," "User control and freedom," and "Help users recognize, diagnose, and recover from errors" heuristics, no violations have been set for those heuristics. Generally, in HE studies, it is possible to have heuristics that are not violated. For instance, "User control and freedom" were not violated in the study results published in [34].

During the debriefing session, the evaluators determined the severity of each of the seven usability problems. The evaluation revealed that the problems are either catastrophic or major, which clearly indicates the EMR interface's complexity. Usability is a quality attribute that measures how simple UIs are to use [20], while evaluation results reveal that interacting with an EMR interface has several catastrophic or major usability issues. As a result, when users engage with the tested tablet-based EMR UI, usability concerns could occur. In general, elderly users—including elderly medical doctors—may be reluctant to use electronic systems due to poorly designed, unusable interfaces [16] [35].

The ability to execute the "drag and drop" gesture is one of the usability problems identified in this research that significantly impacts elderly medical doctors. An earlier study [36] provides additional evidence supporting this conclusion. Elderly people's declining motor skills are to blame for their difficulty using the "drag and drop" gesture [17]. However, both elderly and young novice users may be affected by other usability problems, such as using identical text labels for buttons that perform contrasting functions (refer to problem 1 in Table 3). Young users just starting to use the system might be confused by these similar-looking labels that represent distinct buttons. Still, younger novices won't be affected much after a few tries because of their cognitive ability to discriminate. Younger users might be able to pick up on the various difficulties more quickly through trial and error and by using their mental models to gel with the most recent technologies; however, difficulties for elderly users might be more significant [37].

5 CONCLUSIONS

Applying the HE approach helped determine usability problems that elderly medical doctors might encounter when utilizing a tablet-based EMR user interface. In this regard, we categorized usability problems under their relevant heuristics in this study. As a result, eight usability problems contributed to seven heuristic violations that were discovered. This categorization would contribute to the body of knowledge

concerning the requirements of elderly medical staff concerning the usability of EMR interfaces (namely those that are tablet-based). More in detail, this categorization increases our understanding of the various problems preventing elderly medical doctors from doing their tasks and captures the essence of each usability challenge.

Besides these, the elderly doctors reported other usability problems and were finding it difficult to perform certain gestures, notably "drag and drop." Thus, it is advised that any future EMR designs eliminate or at least scale back the use of these gestures. Besides diagnosing the common violations of heuristics and usability problems, evaluators offered design recommendations (solutions) to address the issues categorized. Such solutions would help offer UI designers insights into future design improvements for the UIs of future EMR systems.

This study evaluated the UI usability of a tablet-based EMR system currently used by elderly medical doctors in a group of hospitals and clinics. As a future work, a UI usability evaluation of different EMR systems would be able to spot new usability problems, expanding our knowledge of the heuristics that were violated and proposing more suitable solutions that suited the newly discovered problems. Additionally, a comparative usability analysis could be made among the different evaluated EMR systems; thereby, generic solutions might be provided for broader EMR systems. Medical doctors conducted this study. Therefore, it might be suggested that this study's limitation is the absence of medical staff other than doctors as evaluators (such as nurses). With the help of various medical staff categories, our future work will concentrate on extending the usability evaluation of other EMR system interfaces, consequently identifying broader usability problems and devising their generic design solutions.

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7 AUTHORS

Hasanin Mohammed Salman is a Lecturer at the department of Information Technology, Catholic University in Erbil, Kurdistan Region, Iraq. In 2021, he obtained PhD degree in Information Technology from "Universiti Teknologi PETRONAS," Malaysia. He received master's degree in Software Engineering, from "Universiti Putra Malaysia" and a Bachelor's degree in Computer Engineering from Al-Fateh (Tripoli) University, Libya. His research interests include human–computer interaction, user experience, and embedded systems.

Firas Husham Almukhtar is the Head of Information Technology department, Catholic University in Erbil, Kurdistan Region, Iraq. Born in Baghdad – Iraq 1971. Has Ph.D. in computer science and Information Technology 2003; from the High commission of Informatics – National Center for Computers, Baghdad. M.Sc. in computer science 1997 form Alnahrain University, Baghdad. Teacher for many subjects, includes:- ICDL, Programming in C++, OOP, Database, Artificial Intelligence, image processing, Multimedia, Data Structure, Web Programming, Data Structure, Networking etc.