The Design and Evaluation of a Home Health Care System (TeamVisit)

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Keywords: Health Care System, e-Heath, User Centered Design, Usability and System Design.

Abstract: The usability of computer systems used in health care is a worldwide issue. Poor usability has been reported as one of the most common problems in human-computer interaction, negatively affecting the workflow of health care. Today, the demand for home health care is increasing. It must therefore be supported with a system that is easy to learn and easy to use. The department of home health care at King Abdullah Medical Complex in Jeddah (KAMCJ) uses a semi-manual system. This research introduced a system called "TeamVisit," which was designed to automate services and to enhance support for workflow management at the KAMCJ. The User Centered Design (UCD) method was applied to design the TeamVisit system. The system was designed in three stages: the first stage identified intended users and tasks, the second stage aimed to confirm whether the system matched user requirements, and the final stage involved initial usability testing of the TeamVisit system. The paper also summarizes the results of each stage. The paper concludes that users were satisfied with the design of the TeamVisit system, finding it easy to use.

1 INTRODUCTION

Home health care comprises a wide range of health-related services provided by health professionals at the patient's home or another place outside a medical facility. Home health care is beneficial in cutting hospitals' operational costs, as providing medical care at home reduces the length of a hospital stay, and reduces the number of unnecessary hospital admissions. Home health care also provides support for the patient's family and improves quality of health.

King Abdullah Medical Complex in Jeddah (KAMCJ) is a hospital in Saudi Arabia that applies the Saudi Ministry of Health home care program. The home health care team arranges appointments for patients registered at KAMCJ and visits them frequently in their home for regular checkups. Currently, WhatsApp is used for appointments and communication and paper forms are used during day visits. Also, patients must use WhatsApp and come to the hospital if they require refill order for supplements or medication.

Poor communication between patients and medical providers (doctors or nurses) could lead to unnecessary excessive treatment causing unwanted side effects (Organization, 2018). A usable computer system enables users to pay attention to their required task rather than to the technology itself. According to Dray (1995), usable systems are easy to learn, easy to remember, and easy to use. They are efficient, minimize the chance of errors, and promote user satisfaction.

The TeamVisit system was designed to enhance workflow and communication at KAMCJ. This paper describes the application of User Centered Design (UCD) to the design stages of the TeamVisit system, which enhanced its usability.

2 RELATED WORK

2.1 Home Health Care

Home health care began in Saudi Arabia in 1991. The Home Health Care program (HHC) was developed by King Faisal Specialized Hospital and Research Center for patients with terminal cancer. Later, in 2008, the Saudi Ministry of Health established a

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Shishah, W., AlJowesir, H., Subh, O. and Hassan, G.
The Design and Evaluation of a Home Health Care System (Teamvisit).
DOI: 10.5220/0010157502180224
In *Proceedings of the 4th International Conference on Computer-Human Interaction Research and Applications (CHIRA 2020)*, pages 218-224
ISBN: 978-989-758-480-0

home health care program to provide health services for all those in need, wherever they may be, to reduce the pressure of hospital waiting times. The high quality home health care service is provided to international standards and according to Islamic social values and traditions (Almoajel et al., 2016).

Different countries employ a variety of definitions of home health care, but perhaps the most useful definition is satisfying people's health and medical needs while in their home by providing appropriate and high-quality home-based long-term or a short-term health care (Genet et al., 2011).

Home health care grew at an annual average of 5.05% from 2007 to 2012 (Gitlin and Piersol, 2015). As the population increased and technology evolved there was a real need to develop new technologies in home healthcare. In the early 1990s, telecare and telemedicine were introduced for the first time. Telecare is the use of technology, such as remote monitoring, to manage risks for the elderly so they can receive help at home and continue to live independently. Telemedicine is the use of telecommunications technology, either synchronous or asynchronous, to remotely consult a doctor or access medical advice. This service may provide valuable help in the homecare sector (Lamine et al., 2019; Lyons et al., 2019).

Many studies have outlined the advantages of home health care. One study, (de Mestral et al., 2019), looked at patients who received post-surgery home nursing, including 23,617 patients, of whom 9,002 (38%) received home medical assistance within 30 days of discharge. Results showed that there was less chance of an emergency department visit or hospital readmission among patients who received home health care services (Abyad, 2017; de Mestral et al., 2019).

2.2 Usability of Health Care Systems

Reports of unusable systems suggest the issue of health care system usability has become a global issue affecting health care workflow and potentially introducing new errors, particularly those technologically induced (Kushniruk et al., 2013).

According to (Riskin et al., 2015; Kellermann and Jones, 2013), a number of problems have been reported relating to human-computer interaction, poor usage, systems failing to meet intended users' needs, terminologies, and workflow. Several attempts have been made, in the past, to foster the development of health care systems and an encouraging and compulsory user-centered system that is more usable does exist. Different methods have been adopted for testing for usability and for assessing systems and their impact on patients' safety. However, (Kellermann and Jones, 2013; Riskin et al., 2015) argue that reports of poor system usability continue.

User interface design must be easy to understand and intuitive in order to prevent usability issues, especially when designing an interface for older adults. A study was conducted in Taiwan by (Chen and Liu, 2017) investigating the intuitive interaction and affordance relationship with elderly users. It concluded that, in terms of usability, designs with the simplest layout are best for elderly users. Consequently, complex and composite arrangements and information presentations that require imaginative association should be avoided in the user interface (Chen and Liu, 2017).

When implementing new systems in the field of home health care, caregivers must be trained to understand how the new system works to support the physical, mental, and medical needs of their patients, and adequate training must be provided for elderly patients for them to accept and adopt the new technological system (Chase et al., 2009). The appropriate awareness, full commitment, and the correct application of user-centered processes and tools are all necessary to ensure success in the process of designing a usable interface (Dray, 1995).

3 METHODOLOGY

The research method adopted in this project is User Centered Design (UCD). This method emphasizes user involvement at each stage of the design process and Kashfi (2010) recommends its application in health contexts. The major focus of UCD is the end users and the needs for which the system will be used. The main goal of this method is to make systems usable and to achieve user satisfaction. The key characteristic of UCD is its iterative nature, in which prototypes are delivered to users regularly for evaluation and enhancement during the design and development process.

According to McCurdie et al. (2012), the UCD process begins with the concept generation stage, in which, once users are identified, a comprehensive examination of their needs is performed in order to understand the use and purpose of the system. Different techniques can be used in this phase such as ethnography, focus groups, and one-on-one interviews.

On completion of the initial investigation of user needs, our project proceeded to the next phase, which is to translate the identified user needs into a set of

functional requirements by designing initial prototypes as simple sketches and wireframes.

The prototypes are then used to collect user comments and feedback, and to get an in depth understanding of the main goal of the system. As our design process continued, designs were evaluated and reframed iteratively with users through the use of walkthroughs and usability testing. User comments and feedback were used to verify that the representation of the system matched user requirements.

During walkthroughs, a facilitator supported users through the process of using the proposed design (Kaye and Crowley, 2000). This helped users to think aloud and provide feedback on the issues and obstacles they faced with the suggested workflow.

For the usability tests, a representative user worked independently in a controlled environment through a set of scenarios representing typical usage of the system, while at the same time thinking aloud, as suggested by (Fu et al., 2002). The facilitator who observed the study, recorded notes on the participants' behavior as well as their comments and issues that arose, helping to detect any hidden requirements and interface design errors. Section 4 will describe how the UCD will be conducted in our work and which techniques will be used.

4 THE DESIGN AND EVALUATION OF THE TeamVisit SYSTEM

The TeamVisit system development team was multidisciplinary, and included an interaction design expert, who also served as domain expert, and three University students with different backgrounds in software engineering, programming, and user interface design. However, other experts and users were involved in different phases of the evaluation. The design of the TeamVisit system was conducted in three stages, as discussed below.

4.1 Stage 1: Identification of Intended Users and Task

The development team conducted a focus group with four users, two members of the home health care team and two members of the hospital's IT department. Focus groups were selected as the most suitable method of data collection as they allow a diversity of views to be shared, developed, and discussed (Heary and Hennessy, 2002). The focus group lasted for approximately two hours. The aim of this stage was to identify the intended users and the main tasks for each type of user. The leader of the development team, who had experience of developing systems and in conducting focus groups, facilitated the group session. The remaining research team members noted comments and suggestions during the session. An example of questions prepared to foster this focus group included: explain the current satiation of work, what are the responsibilities of each member of the home health care team, what tools are currently used, and are there any problems or issues?

Following the focus group, the development team designed a low-fidelity prototype (Figure 1). Then, the leader of the development team conducted a one-on-one interview with the leader of the home health care team. This interview was conducted in order to come to an agreement about the main tasks of the system using the low-fidelity prototype and to elicit initial feedback for the system design. The leader of the development team took notes that were then taken into consideration in designing the next prototype. The development team analyzed the collected data and categorized the evidence.

Figure 1: Low-fidelity prototype in stage 1.

4.2 Stage 2: Confirming the Functional Requirements and Workflow of the Functions

The development team developed a mobile prototype for this stage, as shown in (Figure 2). The team examined the mobile prototype with two members of the home health care team. Each participant examined the features by navigating the mobile prototype and providing feedback, comments, and notes. The development team observed each participant and took notes. The examination of the prototype lasted for approximately two hours, its main goal being to test the workflow of the system's functions.

Figure 2: The mobile prototype in stage 2.

4.3 Stage 3: Usability Testing of the TeamVisit System

A responsive web application was developed (Figure 3) involving two sides: the patient and the caregiver. This was selected in response to the requirement identified in Stage 1 that the design of the system should be compatible with different sizes of screen. A responsive web application fits in any screen size, runs on any device, and works with any operating system. The web programming languages used were HTML, CSS, and JavaScript for client-side scripting, and PHP and MySQL for server-side scripting.

Testing is an important phase in software development, and, for thoroughness, unit testing, integration testing, and usability testing were applied. During development, unit testing was conducted on a daily basis for each feature to ensure that each functionality performed as expected. After completing development, the development team carried out integration testing in order to verify that all functions in the system produced the expected results. Then, usability testing was carried out with five participants from different backgrounds. Before the study, the development team prepared eight test cases to be examined (Table 3). Then, the leader commenced the process by thanking the participants for their participation and then explained the purposes and aims of the research study. Participants were asked to interact with the TeamVisit system to perform the selected test cases. During the testing, the leader conducted a think-aloud procedure by asking users to verbalize their thoughts whilst performing the tasks. The development team members observed each participant and took notes.

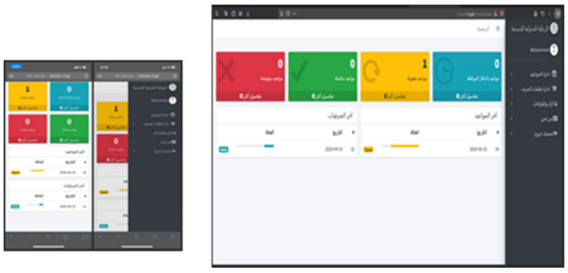

Figure 3: Example of responsive web application. The left image is the TeamVisit system on a mobile screen, the image on the right is the TeamVisit system on a desktop screen.

5 RESULTS AND DISCUSSION

The involvement of users in the early stages of the design process supported developers in collecting useful data for the TeamVisit system. This supports the results of previous studies that highlight the important role of the user in the design process (van de Kar and Den Hengst, 2009).

The focus group conducted in Stage 1 identified the direct users of TeamVisit and the main tasks. The direct users for the system include:

- Head of the home health care department at KAMCJ, who authorizes team members to use the system. (Moderator)
- KAMCJ home health care team members whom the moderator grants permission to log in. (Caregiver)
- Patients registered with the KAMCJ home health care department and a relative who has knowledge of the patient's required data. (Patients)

The use case diagram shown in (Figure 4) shows different ways in which users (patient, caregiver, and moderator) can interact with the TeamVisit system and what tasks they can perform.

Feedback from the interview was highlighted for consideration in future design. For example, rather than specifying the type of user (caregiver, patient) at the login page, log in to the system should be by national ID, for both the caregiver and the patient, so the system can automatically recognize the type of user and move on to the appropriate page. In addition, the design of the system should be compatible with different sizes of screen.

Figure 4: The use case diagram.

In Stage 2 of the TeamVisit design process, the mobile prototype proved useful, as suggested in previous studies (Kaye and Crowley, 2000), for getting comments and feedback from users. In general, the home health care team agreed with most functions of the system and the functional workflow. Further highlighted notes need to be considered in the design. For example, in the current design (Figure 2), appointment bookings can only be performed by the patient. This needs to be changed so that the caregiver can perform the task while the patient responds by accepting or rescheduling. The reason for this is to allow the home health care team to organize visits so they can visit patients who live close to each other on the same day. The main features for caregivers are described in Table 1 and the main features for patients are described in Table 2. Also, the priority status for each feature was identified as (High, Medium and low) which help the development team in the implementation phase.

In Stage 3 of the design process, the results of the usability testing were summarized (Table 3). Five users participated in this study, following (Nielsen, 2000), suggestion that testing with five users results in identifying the majority of usability problems. All the 5 users performed both the caregiver and the patient tasks. The expected time to complete the tasks is 45-50 minutes and users completed the tasks in acceptable duration time between 40 minutes to 1 hour. In general, users seemed satisfied with the TeamVisit system and found it interesting to use. However, there was some apprehension that needs to be resolved in order to enhance the usability of the system (Table 3).

Table 1: The main features for caregivers.

Feature	Feature description and the priority of implementation
Log in	Log in using National ID and password. **(H)**
Profile	view personal information and update contact details and password. **(H)**
Add new patient	Register patients using the required data such as National ID, Medical Record Number (MRN), name, age, gender, location **(H)**
	Adds the order of medications, diet, and medical supplements for each home health care patient
Manage refill request	Manages patients' requests by viewing, accepting, editing, or rejecting. **(H)**
Books appointment	Books appointments to visit patients in their home. **(H)**
Visiting requirements	Fills out the visiting requirements for appointments **(M)**
Messages	Receives text or image messages from home health care patients. **(L)**
Messages status	Applies a status to messages received from patients: read or unread. **(L)**
Charts	Views dashboard charts. **(M)**
Search	Searches using a patient name and searches appointments by date and status (accepted, rejected, pending, completed). **(H)**
Add new caregiver	(Moderator only) can Add/Delete caregiver members. **(H)**
(H) = High priority / (M) = Medium priority / (L) = Low priority	

Table 2: The main features for patients.

Feature	Feature description and the priority of implementation
Log in	Log in using National ID and password. **(H)**
Profile	view personal information and update contact details and password. **(H)**
Notifications	users can be notified of scheduled appointments and receive a response to their refill order requests. **(M)**
Refilling requests	Requesting to refill medications, diet supplements, or medical needs. **(H)**
History	view the past five refill orders or appointments. **(M)**
Responds to requests	users can respond to appointment requests for home visits arranged by the home health care team. **(H)**
Shares location	For each appointment, users can share their current location. **(M)**
Messages	Users can send text messages as feedback or comments to caregiver and upload images to describe their health condition. **(L)**
Contact us	view contact details about home health care team members. **(L)**
Satisfaction rating	The patient can give a satisfaction rating for the service provided (Excellent, Very good, Good, Acceptable, Poor). **(L)**
(H) = High priority / (M) = Medium priority / (L) = Low priority	

Table 3: Summary results of the usability testing.

N	User background	Task given	Time	Notes by development team members		
				Positive feedback	Negative feedback	Suggestion
1	Business administrator	**Test Case 1:** User login. **Test Case 2:** Adding a new caregiver user. **Test Case 3:** Adding a new patient. **Test Case 4:** Caregiver manages refill orders for medication or diet supplement. **Test Case 5:** Caregiver schedules appointment for patients. **Test Case 6:** Caregiver adds appointment's requirement on the visit day. **Test Case 7:** Patient orders refill. **Test Case 8:** Patient sends message.	45 minutes	Adding a patient is really easy and no difficulties were faced.	Appointment status is confusing.	None
2	Dentist		50 minutes	The interface and main functions are easy to use even though there are many scenarios.	None	The refill feature is limited (e.g. no information about dose).
3	Nurse		1hour	Managing appointments is smooth using the search by date and status.	None	Patient history is limited.
4	IT student		40 minutes	The whole system looks good.	Some interface icons (such as the mail icon in the login page) does not give the right user impression.	None
5	Teacher		1 hour	Requesting a medication refill is clear.	Sending messages without receiving a reply is not really useful.	None

6 CONCLUSION AND FUTURE WORK

This paper describes the design stages of a proposed system for the home health care department in KAMCJ called "TeamVisit," which aims to provide automated services and enhance communication between patients and the home health care team. Users were involved at point in the design process and initial usability testing was conducted.

Using the UCD method, users were involved in each stage of the design in order to get appropriate data. In Stage 1 of the design process, a focus group and interview were used to collect data about the intended users and their main tasks. Next, in Stage 2 of the process, a mobile prototype was used to confirm the requirements of the TeamVisit system. Finally, initial usability testing was conducted, which found that users were satisfied with the TeamVisit system and found it interesting to use.

For further research or future work, more usability testing should be performed using other techniques in order to gather more useful information. Also, a field study may be conducted to gather data in a natural setting; this can be performed by observing users while they interact with the TeamVisit system. Furthermore, tests could be conducted with a larger sample of users in order to carry out quantitative analysis of usability problems.

Further features were recommended for development in order to enhance the performance of the system, some of which are highlighted below:

- patient appointment booking, to give them more flexibility;
- live direct messages with a doctor so patients can describe their medical condition and get immediate medical advice; a video call feature would further improve medical consultation;
- an upgrade of the responsive web application to a native mobile application would provide many advantages;
- car tracking of the team member due to visit the patient at home;
- report generation such as number of patients served in each location, downloaded in pdf format.

ACKNOWLEDGEMENTS

Many thanks to all participants of this project and special thanks to Dr. Khalid Alabbasi at King Abdullah Medical Complex in Jeddah (KAMCJ).

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