ORIGINAL ARTICLE

SOFTWARE PROTOTYPING FOR HOSPITALIZED PATIENT PARTICIPATION IN THE MEDICATION SYSTEM

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Highlights: (1) Patient participation mediated by technology is a barrier to avoiding errors. (2) The MedPad prototype is a platform to promote patient participation. (3) The MedPad platform has evidence of execution validity according to experts.

PRE-PROOF

(as accepted)

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SOFTWARE PROTOTYPING FOR HOSPITALIZED PATIENT PARTICIPATION IN THE MEDICATION SYSTEM

ABSTRACT

Objective: to develop a prototype to support hospitalized patients' participation in the medication system. **Method:** this is a methodological study, carried out between March and December 2019, in Fortaleza, Brazil. The study stages were: analysis, design, development, evaluation, and administration. In the first three stages, in addition to the researcher, graphic designers and software programmers participated in organizing the content and navigation architecture. In the following stages, 25 experts (physicians, nurses, and pharmacists) participated in evaluating the software in a simulated environment. The data related to the evaluation were analyzed using the percentage of agreement and the content validity index. **Results:** the MedPAd software had its operating architecture structured in three integrated devices: web service system (for including prescription and medication dispensing data); server (for programming and data storage); and application (intended for use by the patients, with information about their medication therapy). The experts evaluated functionality, reliability, usability, communicability, applicability and efficiency with an overall agreement percentage greater than 90% and an overall content validity index of 0.94. **Conclusion:** the prototype presented evidence of validity regarding the tested items.

Keywords: Patient participation; Patient safety; Medication systems in the hospital; Technology.

INTRODUCTION

Technologies are used in various contexts in the healthcare field, whether in management, patient education, professional training or care. In the context of hospital care, technological resources are intended to make the work process more assertive and faster for professionals and reduce the risk of harm to patients[1].

In the scientific literature, it is observed that the implementation of technologies has generated the concept of Smart Hospital, that is, an environment characterized by the extensive use of computerized and automated resources, which provide agile and more efficient responses to improve the patients' experience during their hospitalization[2]. The

literature on this concept is still recent, but it highlights that the smart hospital service can influence administrative and management policies, as well as clinical decisions, in order to quantitatively measure indicators and generate new value for healthcare[3]. This interlocution between technology, safety and positive experience can be directed to the medication system, which is one of the critical nodes of hospitalized patient care, as it consists of multiple stages (prescription, dispensing, preparation and administration), in which a variety of professionals (physicians, pharmacists and nursing staff) participate in different sectors (nursing station, pharmacy and patient bed)[4].

Given the complexity, medication errors can occur in any of these stages, as shown by a Norwegian study, in which 67.8% of errors were committed during administration; 23.7% during prescription; and 6.2% during preparation or dispensing[5]. Therefore, it is essential to establish containment measures to mitigate such incidents, such as: improving medication systems, proposing environments that favor the concentration of professionals during the handling of medications; and supporting patients' participation in their own care[6].

Researchers argue that patients can be considered the last barrier to avoiding medication errors and, to this end they must be participatory, engaged and informed about their treatment[7]. As patients acquire a higher level of information and become more actively involved in their medication regimen, adherence rates to the appropriate use of medication tend to increase, while reducing the chances of errors, discrepancies and adverse events[8].

Although it may represent a challenge for health professionals, the task of educating and informing patients about monitoring the final stage of medication administration is a primary need, as it meets the very assumptions of training in caring for others, with an emphasis on valuing their autonomy and respecting human dignity, reducing all possibilities of error as much as possible.

This research is justified given that there is a worldwide call for methods/technologies that reduce medication errors in hospitals, as well as placing patients in a strategic position in this process, fostering their autonomy and deliberative capacity regarding decisions about their health. The research therefore aims to develop a prototype to support the participation of hospitalized patients in the medication system.

METHOD

This is a methodological study carried out between March and December 2019. The prototyping process was guided by the methodological framework of Galvis-Panqueva and Mendoza[9], namely: analysis, design, development, evaluation and administration.

The initial analysis stage was aimed at defining the objective to be achieved with the use of the system, which is to integrate the stages of prescription, distribution, scheduling and monitoring of medications into one platform, the latter being aimed at enabling patient participation in the surveillance and monitoring of medications administered to them in the hospital. At this stage, the user/operator profiles and necessary technological infrastructure were also defined.

During the design and development phases, the layout, appearance of the system (colors, texts and images), navigation structure, interactivity and interfaces were organized. The images were created by a graphic design team that used the realism illustration technique. The software's technological and programming structure was created by two professionals in the software engineering field who proposed the operating scheme and data transfer in the final product: Web service system (installed on the computer); Application Programming Interface (API) that provides the application with access to the cloud; and the Application, which provides the information available to the patient (figure 1).

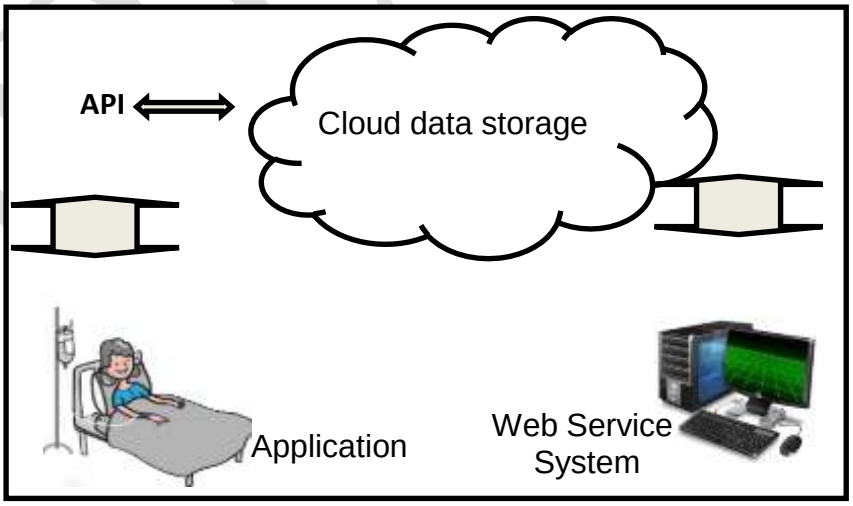

Figure 1 - Schematic representation of how the platform works. Fortaleza, CE, Brazil. 2023.

Source: the authors.

The software was developed using: Python programming languages, with the Django framework for building the server; Java language for developing the application in Android (4.0.3 and later); and the Cloud Vision API for capturing images.

In the evaluation and administration phases, the prototype was tested in a simulated environment with the participation of 25 experts, including nurses, pharmacists, and physicians. The selection of these experts was based on a face-to-face approach carried out by the researcher with hospital professionals involved in the different stages of the medication system. The inclusion criteria followed the guidelines established for validation studies[10] in which only specialists with a score higher than five were chosen. The sampling technique used was snowball sampling.

The specialists were invited to respond to an instrument with responses on a Likert-type scale with the following response options: 1- Not at all appropriate; 2- Somewhat appropriate; 3- Moderately appropriate; 4- Very appropriate; and 5- Completely appropriate. The aspects assessed in the instrument were composed of the following attributes and subcategories: functionality (adequacy, accuracy and interoperability); reliability (maturity and recoverability); usability (intelligibility, comprehensibility and operability); communicability (design); applicability and efficiency of the prototype (time and resources)[11].

The data were organized in the Statistical Package for the Social Sciences (SPSS) version 23.0 and the following were calculated: the percentage of agreement among the experts, with a cut-off of 90% considered valid; and the Content Validity Index with a minimum validity of 0.7812.

The research was approved by the Research Ethics Committee (REC) of the Federal University of Piauí (UFPI) through the substantiated opinion: 3.018.102 and all participants signed the Informed Consent Form.

RESULTS

ANALYSIS, DESIGN AND DEVELOPMENT

To define the name, the product's characteristics were considered, and it was named MedPad – Med referring to the medication/medicine system; and Pad referring to the English word meaning tablet, panel or board, which is the gadget used by the patient. The existence of a trademark registration with the same name was researched at the National Institute of Industrial Property (INPI), and since none was found, the initial proposal remained.

It was decided that data would be transferred from the web-service system to the server and from there to the Application, which would provide records of medication compliance and errors back to the web-service for the production of management reports.

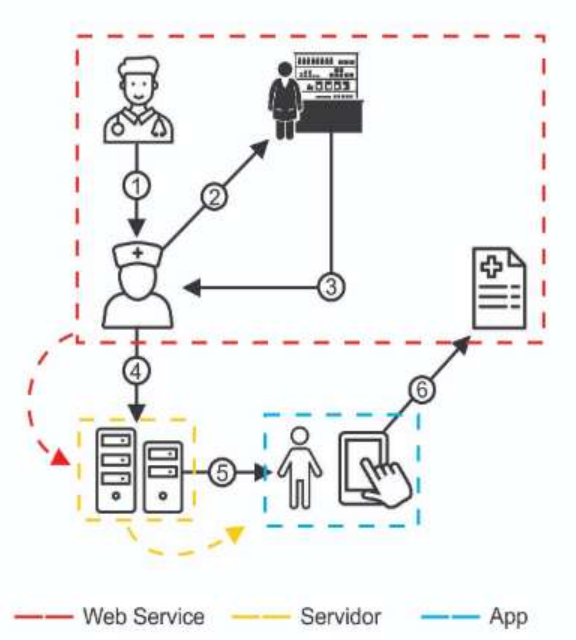

Figure 2 - Architectural diagram of the system. Fortaleza, CE, Brazil, 2023.
Source: the authors.

As shown in Figure 2, the data flow will occur as follows: (1) the physician will prescribe; (2) the nurse will schedule the medications, and from there this information will be transferred to the pharmacy; (3) once the pharmacist accesses the system and dispenses the medications, this data will be returned for access by the nursing staff and simultaneously to the server (4) where it will be stored in the cloud and will be transferred in real time or with updates every 30 minutes to the tablets with the application installed for use by the patient (5); once the patient uses the application, the data will be fed into the medication error report (6) for risk management.

The user will enter the system as follows: professionals will be registered by entering the following data: full name, Individual Taxpayer Registry (CPF) number, professional registration number and numeric password. For patients, the following identifiers will be required: full name, medical record number and mother's name.

Regarding the system's functionalities, the following were defined: access registration for professionals and patients (through login and password with the user's identification data and their access permissions); persistence and consultation (the data will be stored on the server for validation and consultation); movement in the prescription, scheduling and dispensing (with the access licenses protected, each professional may, according to his competence, make additions and corrections to the patient's medication list); confirmation (the patient may view the medication list and scheduled times, as well as confirm whether or not they were administered, and in the latter case, the possible reason).

As for the illustrations, 11 screens were designed, ten of which related to the medication administration routes (intravenous, intramuscular, subcutaneous, intradermal, oral, sublingual, inhalation, ophthalmic, otological and topical) and one with the prototype's logo.

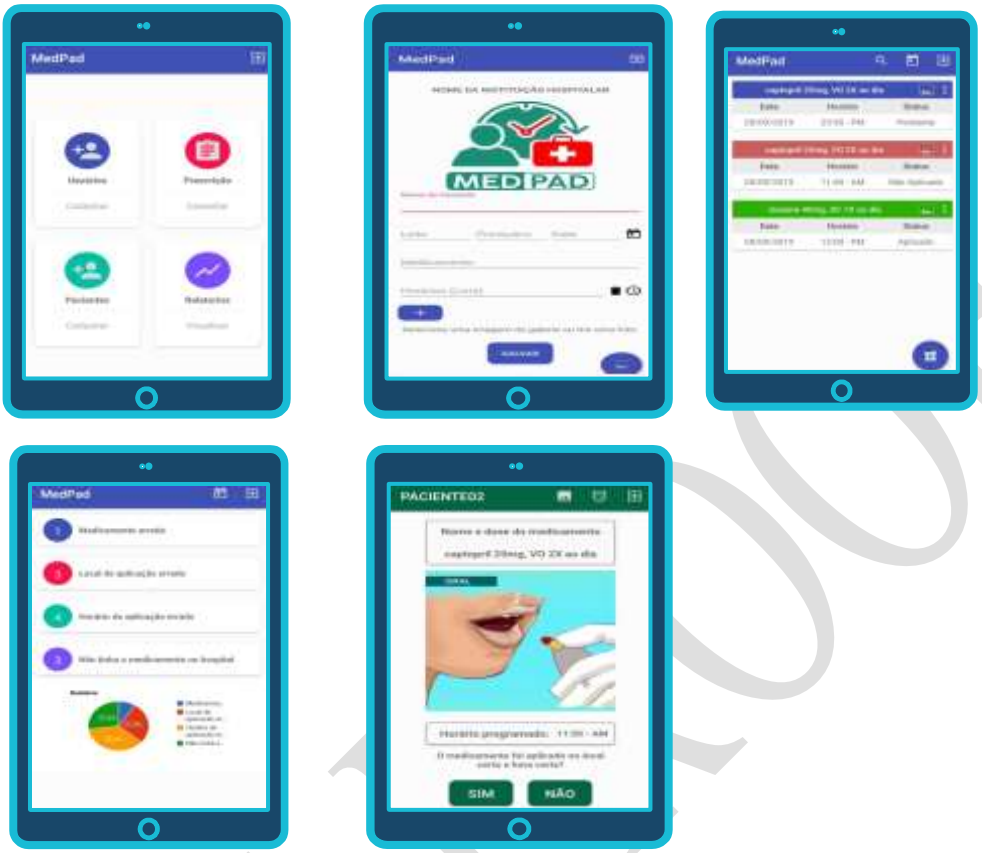

Figure 3 – Representation of the layout of the screens for: registration of professionals and patients; prescription and scheduling; patient access screen; and management reports. Fortaleza, CE, Brazil. 2023.
Source: the authors.

EVALUATION AND ADMINISTRATION

The group of experts who evaluated the prototype was composed of ten nurses, eight physicians and seven pharmacists. Regarding gender, 72% were female; with a mean age of 32.3 (± 9.7) years; more than five years of experience in the hospital area (68%); with a *Lato sensu* graduate degree as their highest qualification (72%).

As for the overall evaluation of the prototype, it was found that the attributes usability, communicability and applicability reached percentages of agreement greater than 90% in all subcategories. Meanwhile, the functionality attribute presented the data security subcategory with a mean score of 3.6 (± 0.5) and 68% agreement, and reliability 4.0 (± 0.5) scored 88% regarding the possibility of data recovery in case of failures. The overall CVI was 0.94 (Table 1).

Table 1 - Mean responses to the evaluation instrument, percentage of agreement and CVI of the experts regarding the MedPad platform. Fortaleza, CE, Brazil. 2023.

Attributes/subcategories	Mean (±SD)	% agreement	CVI*
Functionality			**0.93**
Suitability			
Does the platform meet the objective of supporting patient participation in the medication administration process?	4.4 (±0.5)	100	0.95
Does the platform have the necessary functions to reduce medication errors?	4.0 (±0.4)	92	0.92
Accuracy			
Is the platform accurate in executing its stages?	4.2 (±0.4)	100	1.0
Is the platform accurate in obtaining records of patient participation in the medication administration process?	4.7 (±0.4)	100	1.0
Interoperability			
Does the platform allow information interaction between the web-service system and the application?	4.4 (±0.5)	100	1.0
Access security			
Does the platform provide data security?	3.6 (±0.5)	68	0.72
Reliability			**0.83**
Maturity			
Does the platform not present any failures or errors in its execution?	4.4 (±0.5)	100	0.87
Recoverability			
Is it possible to recover data in case of failures?	4.0 (±0.5)	88	0.79
Usability			**0.99**
Intelligibility			
Is it easy to understand the concept and purpose of the platform?	4.4 (±0.5)	100	1.0
Is it easy to execute the platform functions?	4.4 (0.5)	100	1.0
Understandability			
Is it easy to learn how to use the platform?	4.6 (±0.4)	100	1.0
Is it possible to obtain data to assess medication errors by using the platform?	4.8 (±0.4)	100	1.0
Operationality			
Is it easy to move between interface screens?	4.7 (±0.4)	100	0.97
Communicability			**1.0**
Design			
Does the platform have an appropriate design for its interfaces?	4.3 (±0.4)	100	1.0
Are the colors, fonts, figures and animations used on the screens appropriate?	4.0 (±0.5)	100	1.0
Applicability and efficiency			**0.95**
Suitability to the environment of use			
Is the platform suitable for use in a hospital environment?	4.8 (±0.4)	100	0.93
Time			
Is the execution time on each of the interfaces adequate?	4.7 (±0.4)	100	0.92
Resources			
Are the resources available on the platform adequate?	4.6 (±0.4)	100	1.0

* Content Validity Index.
Source: the authors.

DISCUSSION

MedPad is a prototype of software that integrates with multiple platforms with the aim of providing the best browsing experience and usability for the target audience, both professionals and patients. There is a consensus that this type of technology promotes greater communication and exchange of information between members of the healthcare team, in addition to allowing patients to self-manage the therapeutic process by viewing their medication treatment records[13].

Research has shown that there is an urgent need to develop software adapted to the reality of hospital care, since it is useful for: standardizing information and processes and monitoring indicators more efficiently; streamlining data collection, recording, and storage and recovery activities; eliminating redundancies; and increasing the availability of healthcare professionals to assist patients more safely[14].

The use of technology to increase patient participation with the aim of reducing medication errors has been encouraged in multiple care settings, including the prototype of a remote medication plan in Sweden that enabled greater adherence to the correct use of medication and strengthened bonds between patients and professionals[15].

In the United States, 90% of health services already offer portals for accessing health information for patients, but only 15% to 30% of these use this function. The low digital literacy of users and the lack of a training program to teach how to use the platform are among the limiting factors[16].

According to experts[17], the production and implementation of technologies that aim to engage patients in their care should be greatly encouraged, because even if it is not a resource with guaranteed access to everyone, the fact of being heard is essential and generates a sense of belonging. One of the properties of MedPad is that all records included in the platform (web service and application) will be stored in a database for the production of a report on indicators for Goal 3 – Safety in the prescription, use and administration of medications, of the National Patient Safety Program[18]. It is worth noting that this type of resource is perceived as something that contributes to improving management actions, in addition to being an important contributing factor to a positive climate for managing medication errors[19].

The MedPad proposal suggests the use of a tablet as a gadget to be made available to

the patient because it is already known that they promote greater interactive possibilities, are more visually comfortable due to the size of the projection of images and texts, present good functionality requirements and also increase the chance of interactivity[20,21].

It is argued that the tablet, when used in hospital settings, also has important characteristics for its choice, such as the fact that it allows health professionals to make records alongside the patient, reducing the possibility of forgetting between observation and note-taking, care management, remote access to exams, medication prescriptions and procedure scheduling.

The access security item tested in this prototype received an evaluation below the cut-off point. Among the strategies that can be used to reduce the possibilities of data leaks and increase the confidentiality and privacy of information, we can mention the HoneyDetails model, which uses a proactive defense mechanism using deception techniques in the algorithms to deceive the hacker in all their access possibilities[22].

The inclusion of technology in the hospital environment will not solve all the problems associated with healthcare insecurity, mainly because there are at least two generations of people involved in the process of "knowing how to use" technology, namely digital natives (those who were born adapted to this reality) and digital immigrants (who prefer conventional methods and, although they use them, are always suspicious of the effectiveness of technology)[23].

Therefore, it is recommended that, in order for the MedPad prototype to work in a real scenario, the level of digital literacy, previous experience with computer technologies and the patient's desire to actively participate in their medication therapy be measured as a preliminary stage.

Although there are no records in the scientific literature on the development of a similar platform, this study used expert professionals to check content and appearance validity, which is a common procedure in other technology production research[24,25]. It is admissible for developers of a technological product to submit the prototype for analysis by subject matter experts who have experience in the area of approach, as this increases the possibilities of detecting improvements, as well as favoring the creation of material tuned to the demands of the real world[26].

The limitations of the research include the fact that the MedPad was not operationalized in a real environment, as well as the evaluation of the platform by software

analysts. However, it is considered that the inclusion of this technology would require physical, structural and cultural changes in the work of the health organization beforehand, which would not be possible to achieve in a short space of time.

Among the implications that the technology developed here could contribute to clinical practice, the following can be listed: better adherence to prescribed medication treatment; reduction of medication errors, especially administration errors; increased patient participation in their therapeutic process; improved communication between professionals and patients; and greater reliability in electronic records.

CONCLUSION

It is therefore consolidated that the MedPad prototype presented high percentages of agreement among the judges for the items functionality, reliability, usability, communicability, applicability, efficiency and content. It is suggested that its implementation be considered in future research as an effective contribution to improving clinical practices and the interaction between health professionals and patients.

It is suggested that, in later stages, MedPad be incorporated into other interactive modules for the patients, such as access to direct communication with professionals directly involved in their care, monitoring of exams, a system for assessing the quality of multidisciplinary care and automation and entertainment tools directly linked to the platform, so that the hospital environment is also accessible in the same application.

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Sherida Karanini Paz de Oliveira - Writing - review and editing.

Eugenie Desirre Rabelo Neri - Writing - review and editing.

Edna Maria Camelo Chaves - Writing - review and editing.

Joselany Áfio Caetano - Writing - review and editing.

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