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Design of a Mobile Application for Transfusion Medicine

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Abstract

One of the most frequent error in transfusion medicine is the failure in verifying the patient´s identity prior to transfusion. This paper describes the design and development of a Mobile Application (MA) for transfusion medicine. The app uses barcode and QR reading technology for the verification of the patient's identity and the administration of blood components when making a blood transfusion. Physicians, developers, technicians of transfusion medicine and a User Centered Design team participated in the design. The inclusion of end users was fundamental to get full representativeness of their workflow. The project was based on agile methodologies of project management and software development.

Keywords:

Blood Transfusion, Patient Identification Systems, Patient Safety

Introduction

Today transfusion medicine has become a safe and essential practice in hospitals, but it is a process in which the slightest mistake has the potential of causing great morbidity or even death. A study in New York estimated that 1 in 12,000 transfusions are caused by ABO compatibility mistakes. The Serious Hazards of Transfusion (SHOT) reports in England showed that the risk of death from transfusion in 2012 was 1 in 322,580 transfused components and a had a morbidity greater than 1 in 21,413 [1, 2]. Approximately 70% of incorrect blood components administration occurs in clinical areas. The failure of the final check of the patient's ID bedside is one of the most frequent error. The patient's identity verification is a critical point to provide security [3, 4, 5, 6, 7].

The use of new technologies is one of the best strategies to avoid this kind of mistakes. The barcoding technology allows increasing patient safety with the verification of their identity at the time of taking a new sample and administering a blood component. Like this, it becomes a physical barrier that allows errors reduction in the stages of the circuit and the improvement of the product's identification and correct patients rate[8, 9, 10, 11].

Currently, several papers describe the creation and use of barcode systems with Personal Digital Assistant (PDA) systems, but no published works were observed allowing the use of any Smartphone or tablet device with Android operating systems (OS) in the area of transfusion medicine [8, 9, 10, 11].

The purpose of this paper is to describe the iterative design and development of a Mobile Application (MA) that will be supported in Android OS, which uses bar code and QR reading technology, for the safe administration of blood components when a blood transfusion is performed. We will describe the current transfusion process in our institution and then the one addressed by the MA.

Methods

Setting

The Hospital Italiano de Buenos Aires (HIBA) is a non-profit healthcare academic center founded in 1853, with over 2,700 physicians, 2,700 other health team members (including 1,200 nurses) and 1,800 administrative and support employees. The HIBA has a network of two hospitals with 750 beds (200 for intensive care), 41 operating rooms, 800 home care beds, 25 outpatient clinics and 150 associated private practices located in Buenos Aires city and its suburban area. It has a Health Maintenance Organization (Plan de Salud) that covers more than 150,000 people and also provides health services to another 1,500,000 people who are covered by affiliated insurers. Between 2013 and 2014, over 45,000 inpatients were admitted to its hospitals, there were 45,000 surgical procedures (50% ambulatory) and 3,000,000 outpatient visits. In addition, the HIBA is a teaching hospital, with over 30 medical residency-training programs and 34 fellowship programs. There are currently 400 residents and fellows in training.

Since 1998, the HIBA runs an in-house developed health information system, which includes clinical and administrative data. Its Electronic Health Record (EHR) system, Italica, is an integrated, modular, problem oriented and patient centered system that works in different clinical settings (outpatient, inpatient, emergency and home care). Italica allows computer physician order entry for medications and medical tests, and storage and retrieval of tests results, including images through a picture archiving and communication system. It has been recently certified by the HIMSS as level 6+ in the Electronic Medical Record

Adoption Model, being the first hospital in Argentina and the second in Latin America reaching this stage.

The HIBA Transfusion Medicine Service (TMS) is composed by 7 staff physicians and more than 30 transfusion medicine technicians (TMT), who works distributed in 3 shifts. At each shift, 4 technicians make rounds through the hospital performing the requested procedures, while others support the process in the MTS. They carry out an approximate of 110 transfusions of hemocomponents daily, and receive approximately 50 blood donors daily.For the registration of donors, recipients and transfusions they use an in-house system called HEMOTRANS®. It does not currently interoperate with the EHR, although its developers along with the Department of Health Informatics are working on an integration plan. The HEMOTRANS® system is responsible for crossmatching the information between patient' samples and donors. It also stores hemoproducts intake and generates reports.

From October 2015 to November 2016, 38,663 transfusions were performed in HIBA. This is equivalent to an average of 3221 monthly procedures and 110 daily. In that period, 15 transfusions adverse reactions (present within the initial 15 minutes after the transfusion started) were recorded in structured entry forms within the HCE.

In order to understand the current circuit of transfusion medicine, meetings were held in a multidisciplinary team conformed by health informatic physicians, MTS staff, TMTs and usered centered designers. The current transfusion process and the steps to be taken to address the design of future application were agreed. Prior to submitting the request to the developers, test mockups were performed and iteratively modified with the TMTs.

The current transfusion process:

1. The physicians make the transfusion request from the EHR. An single request may contain different types of practices (for example 2 units red blood cells and 7 units of platelets). The order also has the emergency status of the patient, and a summary of the hematologic status of the patient.
2. The TMS coordinators print all the transfusion requests and distribute them among the technicians according to their availability. They print the informed consent and barcode labels with patient identification from the EHR and verify in HEMOTRANS® if they have already been grouped within 72 hours prior to the transfusion to be performed. If this is the case, they use these stored samples to group the donor's blood. When there is not a registered sample, a blood extraction is made. This is used for serological follow-up is and blood grouping to corroborate the group and factor before the transfusion is done. Each tube is identified with the respective patient identification label. The results are then entered into the system and in the EHR.
3. In the TMS, the blood product bag is selected from the blood bank, and barcoding is performed on it from the HEMOTRANS®, in order to subtract the product from the stock and to check its compatibility with the patient's blood to be transfused.
4. The next step happens in the patient bedside. His identity (name and date of birth or identification bracelet against the paper order) is checked verbally and if they're correct the blood transfusion is performed.
5. If there is a transfusion reaction in the first 15 minutes, the TMT registers it in the EHR and the medical team is notified.
6. The last step happens when the TMT closes the order from a desktop computer generating an automatic progression note with all the transfusion process' data.

Results

Design and development of the MA

In August 2016, a team of resident physicians from the Health Informatics Service with TMT and doctors from the TMS defined the steps and activities that formed the process of a transfusion.

The MA was designed by a team of health informatics physicians, software developers and a user centered design (UCD) team, with the insights of transfusion medicine physicians and technicians.

The project was based on agile methodologies of project management and software development. Subsequently, weekly personal interviews were conducted with 10 technicians to deal with the details of the process. They were accompanied on their daily visit and the process of realizing several transfusions was observed to understand their complexity and to detect problems and opportunities of future implementation.

Layout Instance

The health informatics team generated a Project Charter document indicating the project scope and magnitude, and a Gantt chart setting the project time frame. Through the software Balsamiq® MA several mockups series were generated.

Mobile application prototyping instance

The mockups were tested with the TMT, and modified iteratively according to the tests results. The first series of mockups were in low fidelity, the followings improved their quality. With the mockup final version, a PDF document (portable document format) was designed, emulating the workflow and functionality of the final application, forming a high-quality test application.

Tests of MA

This instance allowed users to test the AM with a smartphone before starting its development. To this end, different use cases scenarios were created with specific tasks to be performed in TMS. The TMTs that were involved in the design process of the MA were not the same than those who

tested the final version, to avoid any bias. 5 TMTs were gathered and a smartphone was given to them, along with the task to be performed. The TMTs successfully completed the process with very good acceptance. The design team filmed them, with their consent, to obtain more qualitative conclusions later.

Development Instance

Once the TMTs and sponsor approval was obtained, a development request was made to the development team who are currently completing the web application developed with Ionic Frameworks v1 and AngularJS v1.3. Material was used as a template (extension of the Ionic Framework) [12, 13].

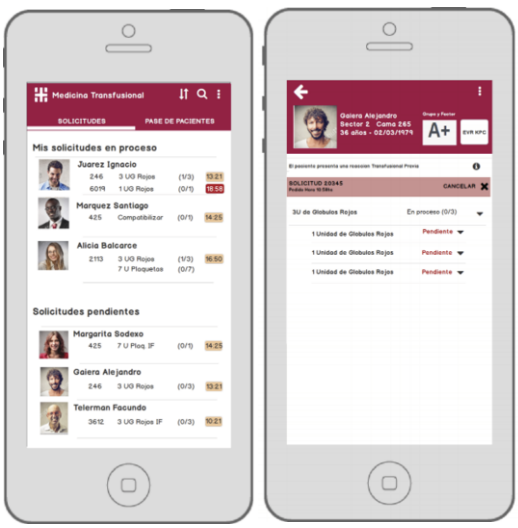

Figure 1 - Main menu and patient space

Workflow in the mobile application

The TMT logs into the AM by entering username and password. When he starts his work shift he can view the worklist of all the products requested in the EHR, without the need to print any order on paper. He selects and assigns to his own worklist the requests in with he will work. If there are any pending procedures from another work shift, there is a "patient handoff" where the TMT takes the patient and associates him to his own work list, with the purpose of allow continuity of care. The list is configurable by request creation's hour, request urgency and sector from where it was generated. The requests can be grouped by patient, if there are several of them for the same patient.

As can be seen in Figure 1, when the TMT clicks on a request on the list, the next screen of the app is the "Patient Space". On its header contains patient's name, date of birth, hospital location, allergies, infectious isolation, blood type, updated personal photo, among others. The "Patient Space" body contains the requests and the different actions that can be made through the app.

Depending on the request, the MA's main actions are:

- Sample: This option allows the technician to perform barcoding on the patient's identification bracelet and on the label of the newly extracted sample tube by checking that the labels are on the correct patient. This blood grouping is serologically monitored and a new corroboration of group and factor, genotype and detection antibodies is made prior to transfusion. (Point 2 of the process described above).
- Transfusion: This option enables a blood product transfusion. It needs the identification of the patient, the request order and the product to be transfused. The AM can read any type of barcode identification or QR codes. If there is any data inconsistency at the time of the barcoding the application gives an alert message and registers it. Once the first 50 ml of the transfusion are in the patient bloodstream, the TMT registers if there was any transfusion reaction and generates an automatic progression note from the application directly into the EMR. (Point 4 to 6 of the process described above)
- Deliver: The transfusion medicine technician transfers the hemoproduct, for another technician or nurse to perform the transfusion later. These cases are usually given in the operating room or in the neonatal care unitPostpone: It happens in any situation when the transfusion can not be performed. It allows the TMT to register this in the. Before the AM this was recorded with a manuscript evolution in the EHR.

Bedside, according to the circuit that is being performed, the AM indicates the steps to complete. The AM allows the tracking of the entire process and provides the possibility to see the previously performed procedures, report adverse reactions and generate a direct record in the EHR. By having instant communication via Wi-Fi each of the procedures impact in the form of CDA (Clinical Document Architecture)[14] and allows its visualization to the other members of the health team. In this way the process was complete without the need to print paper orders.

Discussion

This paper describes the design and development of an AM that will allow to assist the MTS in their process. It is impossible to create a representative tool without the users participation involved in the task. The user centered design area is increasingly involved in AMs production, trying to make it easier to learn, simpler to use, and gain a good acceptance and perception of utility by users[15][16][17]. This design was made by constant and iterative work with end users of the application. The design team aim was for the system to be able to achieve the goals set with a balance

between systematization and flexibility. We achieved a good level of satisfaction for each of the TMT participants with whom we worked. The field of health is gradually adopting user centered design strategies so that computer applications match the tasks or activities for which they were designed [18].

According to literature, we need to make more and more interactive designs with multiple versions, tasks and environments, including the user at the beginning of the project and then carry out product evaluations aiming to improve quality, effectiveness and efficiency [19].

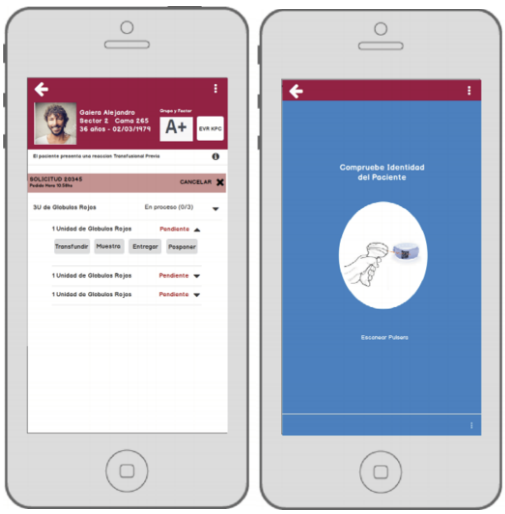

Figure 2 - Main actions in the "Patient Space" and "Barcoding of an identifying bracelet"

The application will be responsive for both smartphones and tablets that use Android OS. The application will be available within a package of functionalities that are being designed in our institution. Currently we have an MAs already implemented for the patient's transfer by the stretchers who perform barcoding on the patient's bracelet and the place of destination where he has to be taken. Another MA is also being completed, which nurses will use to check the "5 correct" when giving a medication, taking vital signs of the patient and other activities performed by the nursing area. This set of applications interact with each other, generating greater communication in the health team, better continuity of care and a quick online update in the EHR.

Limitations

The transfusion medicine MA is still being developed, so the use cases were made with mockups in a test environment. They were not immersed in the real work scenario, with the patient, with the transfusion kit, with the TMT wearing latex gloves, a particular Smartphone to read the appropriate barcode labels (with a suitable camera, with good Autofocus time, battery life and processing speed) or the hospital's Wi-Fi network.

Future lines

We aim to carry out next studies with qualitative methodologies in user satisfaction after use it in real scenarios. We aim to increase transfusion adverse reactions records; provide greater control at the patient's bedside, improving the effectiveness and efficiency of the transfusion process. We also want to analyze the best strategy, contrasting BYOD vs. the purchase of devices and see which is the minimum hardware requirement when choosing a smartphone [20].

Conclusion

There are multiples devices and applications that represent the workflow for transfusion process using barcode techniques. We design a mobile application applying usability techniques being responsive for smartphones or tablets that use Android OS. We expect this AM to be a tool that helps TMT, achieving greater security in the transfusion process, reducing errors in critical points, improving communication between the different actors involved and facilitating the daily task.

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