Framework for development triages through mobile applications

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Abstract

The emergency triage is being implemented due to the congestion of the emergency services, for several reasons, such as: easy access to the patient, demanding an immediate diagnostic and medical aid, prioritizing severely ill patients rather than patients with minor problems that make improper use of the emergency areas. The objective is building a system, integrated to the main system of health organization, for management of emergency triage. To do this, we have analysed and developed a system which allows us to evaluate patients through a mobile application. Results suggest that the integration of emergency triage to mobile application, helps to improve and optimize resource management and decrease the response time. In conclusion, this system optimizes the resources implemented as well as an increase of customer satisfaction.
Keywords: Triage, medical emergency, mobile devices, eHealth.

1. Introduction

The incessant evolution of ICT, joint with the increased of the use of smartphones and tablets [1], have helped to automate processes that, until recently, have been made on paper. One of the areas that has suffered more progress on this aspect is related to the health sciences as it is shown in several reports have shown that one of the areas with more progress on this aspect is related with the health sciences [2]. One of the consequences of this progression is the emergence of the mHealth which has led to significant advances in health sector. According to the World Health Organisation, nearly 90% of the world population could benefit from the opportunities offered by mobile technologies on health area, due to its reasonable cost for the majority of the population [3].

One of the latest reports made by the IMS Institute for Healthcare Informatics, where it is study the significant increase in applications, shows that there are more than 23.682 applications related to healthcare. A further analysis of this applications shows how 7,407 of the applications can be categorized as Healthcare Professional (HCP) oriented, while the remaining 16,275 apps as consumer/patient oriented. That means that 33% of published applications are for professionals and 66% for patients [2] [4].

Despite the progress made in this area, some professionals highlight the need of promoting the use of these apps in the current healthcare system as an integrated health management component. However, most of this applications need a process of 'healing' and evaluation of scientific quality to know the level of effectiveness of these, and the best way to obtain those results is through the analysis of the results obtained with its use [5] [6].

On the other hand, if we take a look to the emergencies management methods we can find that triage is used on medical emergencies and disasters. This method of evaluation consist on a set of rules to evaluate the criticality of each patient, assigned a level of priority based upon its medical condition [7]. Nowadays, the triage system is being implemented in emergency departments of hospitals and health centres in order to improve and streamline emergency services, optimizing the management of resources, avoiding saturation of the emergency and, which is more important, increasing the degree of patient satisfaction. It is for that reason that the aim of this paper was to design, develop and evaluate a technological tool based on triage.

Before starting the development stage, it was necessary to make a deep analysis of triage process in order to develop a framework for mobile devices to know all the needs and try to adapt them to a small screen. After that, it was developed the application taken into account a user-friendly interface reducing the number of transitions between screens. Finally, as we validated our hypothesis, we applied the developed system to a real case with the purpose of setting the level of satisfaction of medical staff with the application.

The paper is divided as follows: Section 2 contains the analysis of prior researches made on mobile applications area and triage methodologies. Section 3 shows the methodology followed to develop the system. Section 4 shows the analysis of the proposed system. Section 5 shows the resulting application, and the paper finishes with the discussion and conclusions obtained through the study.

2. PRIOR RESEARCH

2.1. Mobile classification categories

The World Health Organisation considers mHealth as a component of eHealth and defines it as "medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices" [8]

Due to demand the global Mobile Health market has started taking shape. Because of this demand, a regulatory normative for mHealth has been developed in the European Union where it is set the regulatory framework for medical devices [8]. Mobile health services can be categorised into two broad areas: Solutions across the Patient Pathway and Healthcare Systems Strengthening. Solutions across the Patient Pathway - Wellness, Prevention, Diagnosis, Treatment and Monitoring, entail direct touch-points with patients. Healthcare Systems Strengthening solutions - Emergency Response, Healthcare Practitioner Support, Healthcare Surveillance and Healthcare Administration, do not involve direct interactions with patients, but are primarily aimed at improving the efficiency of healthcare providers in delivering patient care [9,10].

There is no doubt that the application development in health field can be very advantageous for society. Among the possible advantages for patients, the quick access to information and training on issues related to health, allows to monitor variables directly from patient's home, facilitating the following-up of treatments and its control. Analysing the applications from a professional point of view, an access is provided to the concrete information on consultations facilitating decision-making. Also, available tools allow a specialist consult outside of the medical centre, either in the homes of patients, health centres, rural clinics or emergency services.

However, despite its many advantages, its use can also lead to a number of drawbacks, mostly due to a risk of make a wrong decisions due to the managed data, the dependence on a terminal rather than knowledge itself and, which is most important, the risk of breach of confidentiality in case of the lost of the storage systems with individual data.

2.2. Triage methodologies applied to emergencies

Triage systems are used in different areas like catastrophe and urgencies and emergencies. Some studies have centred in Medical response planning for terrorist acts though the typical injury pattern and the delivery of care [11]. The US has introduced and practiced the system triage system in medicine in since 1960 [12]

There are different type of triage System, one of them is The Manchester triage System [13] [14] in different areas, other system the triage is The Andorrano Model used to the Spain [15] others important system triage are the Australian Triage Scale (ATS) [16], the Canadian Emergency Department, The Triage and Acuity Scale (CTAS), the Manchester Triage System (MTS), the Emergency Severit Index (ESI), the Triage Spanish System (SET) adopt by Spanish Society Emergency Medicine (SEMES) from del model Andorra triage system [17].

There are different authors that they have studied this topic. Among the works that we can indicate they are the following ones.

In case the urgencies and emergencies, they have been realised different studied based in used to triage like tools of support remote to medical assessment [18] and like remote triage an emergency management information Integration [19].

The using this system like support in medical telephone triage has been compared, permitting a subsequent improvement patient behaviour [20] [21]

Recently for improvement management the emergency medicine in the hospital is being used the analysis of data mining and statistics technical like clusters analysis [22] or by means of using Bayesian assessment of triage at a level I trauma centre [23] other proposal is selection of patients for clinical trials through an Expert system that helps to select patients for clinical trials based an interactive web-based system.

Other works have been object like elements the support learning of new professionals [24] thought of specialisation course with end the improvement quality of rating [25].

In the last year, there are important development applications with artificial intelligence in areas the medicine in the area not is less. The using Expert system in development Telephone triage [20]

The classification of patients through triage systems in a lot of case is activities of the nurse belonging an emergency service, different studies indicate that with major attributions of this professional are the assessment of the patient's healthcare status decision-making. This process that demands clinical knowledge and experience.

Furthermore the nurse is capable of organising the workflow of patients' development of triage according to priority of the service demands and rendered care, classifying them effectively [26] [27].

These previous researches show the evolution in this field, there is necessary to continue improving emergency medicine [28, 29].

3. METHODOLOGY

When conducting research we have started from a number of assumptions that can be used as the starting point for the design and implementation of the system presented in this paper, which are:

- H1: The use of mobile triage tools facilitate the professionals work.
- H2: The set of tools and the use of mobile health techniques reduce costs.
- H3: The use of mobile tools improve process management.

For conducting the research we have analysed several existing methods of triage, and we have focused primarily on the Andorran Triage Model (MAT) as it is the most used by the Spanish health professionals

It has also performed a preliminary analysis of the various existing mobile platforms on the market that facilitate m-health.

From both studies it has developed a system to analyse the whole process of evaluation of the patient in the emergency room area (data acquisition, processing and subsequent presentation of results).

Finally, we have justified and evaluated our hypothesis, which have been stated above.

4. REQUIREMENT ANALYSIS AND SYSTEM DESIGN

In hospitals and health centres the speed on information access makes easier the assistance to patients. For that reason, we have developed this system to try to help on this issue.

To ease the scalability of the system, this has been divided into three different parts interconnected between them: The first part contains the medical history of the patients; the second part contains the triage rules and the last part is the different devices which can access to the information.
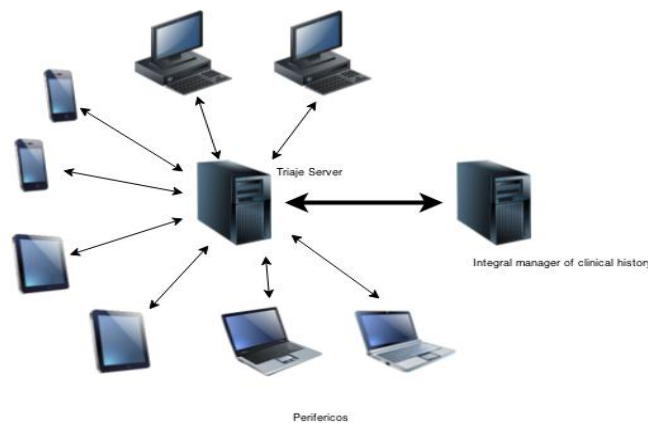

Fig. 1. Connexion of the system

4.1. Requirement analysis

As was mentioned there are different types of triage, it can be of three levels, four levels and five levels, both the four and the three levels are not as efficient as five level, hence the triage of five levels is the most used [30]. Thus, levels of accident and emergency triage and more specifically the Andorran Model of Triage (MAT) is structured five levels.

The level 1 or critical is denoted by red, it indicates that patient requires urgent medical attention, the level 2 or emergency is denoted by orange where patient care must be attended immediately by the nurse and each seven minutes by team medical staff.

The level 3 or urgency is denoted by yellow, it indicates that patient care must be make in less than 15 minutes.

The level 4 or standard is denoted by the green, where patient care may take up to 30 minutes and level 5 or not urgently indicated in blue, the patient care must be make in less than 40 minutes [31].

Although in the study presented by Forsgren [27], where the nurses are the users of triage, showed not only a high degree of job satisfaction (88%), but also an important degree of dissatisfaction due to a heavy workload and lack of competence.

4.2. Integral manager of clinical history

The integral manager of clinical history is a set of the different servers which permit to doctor and nurse to do different things. They can see clinical history of patients and diagnostic test results, such as for example x-ray, blood test, result of others areas, etc. It also allows written new clinical episodes, and order diagnostic tests.

Besides we should not forget that this clinical history can be the Primary Care Attention or the Specialist attention and those systems should promote interoperability.

4.3. Triage Server

The triage server handles the management of patients along their stay in the emergency centre, receiving and processing the information and returning the level of the emergency in the shortest time. To prioritize and allocate the resources the system has been equipped with an expert system which processes all the information through rules assigning the patient level.

At the sometimes the systems consult the patient information directly from the integral manager of clinical history.

Finally, and once the patient is ready to be discharged from the medical centre or it has been sent to other hospitality dependency, the information of the triage will be integrated with its clinic history.

This management of triage system has been developed following the pattern Model-View-Controller (MVC), using Java language to develop the system, using apache tomcat as a web server and MySQL as data base. With regard to the expert system, it has been implemented thanks to JruleEngine.

4.4. Mobile application

The last part of the system is the mobile application, which is used ease the labours of manage the triage information. To make this possible, the application will share information with the triage server.

The application has been developed using the SDK of iOS, provided by Apple, using as a programming language Objective-C.

At all time, we have followed the design patterns and recommendations given by Apple for iOS system, using as reference the clarity and depth in design, keeping in line with the rest of the interface devices. Orientation is horizontal, because it allows greater flexibility of space for provide intuitive menus, in which several graphs can be displayed simultaneously.

To ensure that the application works on as many mobile devices, we has designed an adaptable interface to the screen size, which redistributes the elements depending on size.

In addition depending on the user's role within the organization (doctor, nurse, etc.), the system will provide a job profile, as this condition the time tracking patient care.

In cases where the patient presents a critical situation or Level 1 is evaluated by the mobile device itself which improves response times by not having to consult the central server analysis.

Finally, to carry out the process defined our system is need of programming an interconnect layer between the clinical history server and the triage system.

5. RESULTS

As a result, the application has been divided into 5 different screens: Login, list of evaluated patients, triage, historical data and notifications.

5.1. Screen of login

This first screen allows to access to the system information. Taking into consideration that the access to the medical information of the patients must be restricted, only authorized members can access to the application. To control this access the credentials of the user will be checked on a database located on a remote server. This server is the responsible of store all the information of the patients and users. On this mode, the information will be not stored into the device for security reasons.

Also, the user is informed that the use of this application and the computer system is attributed to him by his status as staff of the company, complying with current regulations in LODP [32].

5.2. Screen of patients list

Once the user has been logged correctly, the main screen of the application is shown. To help to identify the patients, this screen has been divided into two sections: List of not evaluated patients (NEP) and list of evaluated patients (EP). To ease the navigation between both sections, the screen has been provided with a dialog box which allows changing the list with only one click.
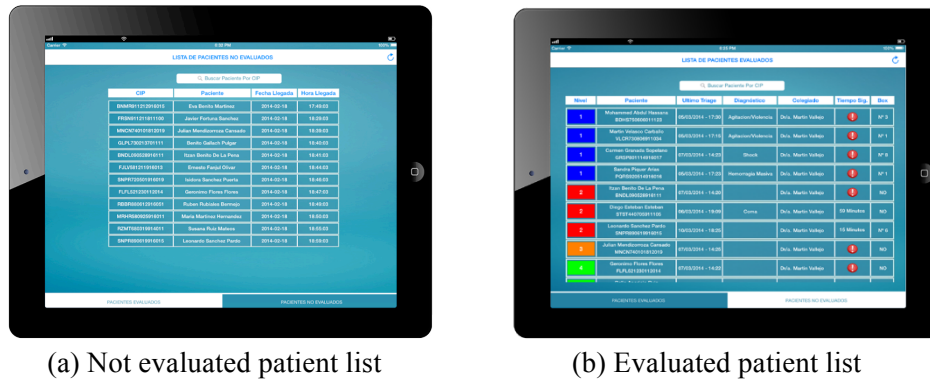

(a) Not evaluated patient list   (b) Evaluated patient list

Fig. 2. Main application screen

As can be seen on Figure 2, there are some differences between NEP and EP lists. Those differences are mainly caused by the amount of patient information of each case.

- Not evaluated patient list (Figure 2(a)). Shows the information of the patients that are arrived to the emergency centre for a medical attention but have not been evaluated yet. For that reason, the information showed on this section is: Personal Identification Code (CIP), name of the patient, date and hour of arriving. To prioritize patients who have arrive earlier, the list is sort by arriving time, being the first arriving at the top of the list. If a patient of this list is evaluated it disappear of this list.
- Evaluated patient list (Figure 2(b)). Shows the information of patients that have been evaluated by a medical specialist. The information show on this list is: assigned triage level (from 1 to 5), which is shown as a number and with a colour corresponding with the Andorran Triage Model (MAT), the name and CIP code of the patient, the name of the professional who attended him, the diagnosis of this first evaluation, and the number of the box where the patient is.

### 5.3. Screen of triage data collection

To access to this section is necessary to press on one of the patients of the previous lists. Once inside of the section, a formulary is shown where the specialist can pick-up the information about the patient exploration. This formulary has been divided into four different sections:

1. The first section contains a basic information about the patient as name or age among others.
2. Second section shows information about date and time where was done the previous triage evaluation, making easy the transaction between evaluations done.
3. The third section shows information about the reason of assistance to the medical centre. To reduce the time of fill the information in case of serious injury, at the beginning it is shown a list of 8 priority cases, all of them classified as level 1 of gravity. Following this list of cases a formulary to pick-up the information about the exploration of the patient. The information collected on this section reflects the level of pain, its location, the scale of this and other factors as reflected medical history and current medications and allergies. This information will be proceeded in order to known the current situation of the patient.

4. The fourth section contains the clinical assessment of patients where information related to the vital constants and signs are collected. This information is essential for an efficient diagnosis. It is important to note that this information is not needed in cases of a priority patient where the time of response is essential. In those cases where the patient need to be attended, this section shows an option to assign a box directly to the patient. In this case the disponibility of a free box is checked with the remote data base.

5.4. Screen of historic information

From the list of patients it is possible to access to this screen, where it is possible to check the historic values of the patient. The information can be displayed in two different ways: Through the form of the last triage performed (Figure 3(a)), or through charts analysis (Figure 3(b)). This last one will enable access to patient information and check the evolution of parameters such as temperature throughout the patient's stay.
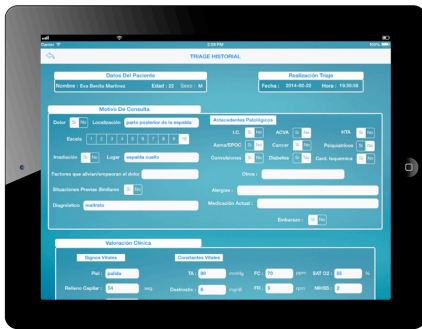
(a) Historic information through form **(b)** Historic analysis through charts

Fig. 3. Historic data

5.5. Notifications

Finally, the application generates notifications that serve to alert the responsible for performing a new triage, when a new patient comes into the emergency department. To ensure that the application is updated each time a query is performed on the database server, a timer every is initialized each 60 seconds after which it is checked whether there are patient in waiting to be attended.

6. DISCUSSION

An extensive use and promotion of interoperability is, in our opinion, the main advantage of our approach. Although there are numerous proposals about mobile systems in health [2], the main difference of our system is that it allows adapting to these three ways (information in real time, mobile devices and desktop devices) at the same time.

At the methodological level, this work contributes submitting and implementing a working method, as it is triage, which is an important evaluation tool in time-critical situations and display the information in an efficient manner.

To validate the application, in the construction and implantation of the system, as well as the development of its interface, it was essential to make the validation with the purpose of verifying its effectiveness. For this, two types of validations have been carried out:

- Technical validation. It has been verified that the results obtained are consistent with the theoretical results in each one of the phases.
- Practical validation. This validation was made in two levels:
  - Clinical. In the presence of a determined real case, which has been previously diagnosed.

   o Satisfaction. User's satisfaction from the point of view of the application's usability, handling, security, questions, etc.

Nevertheless, a drawback has been detected in this system: the necessity to provide the mobile application access to the clinical server in order to be able to evaluate patients. However, this could be solved incorporating the proposed multi-agent to transform the process of evaluation.

Another critical issue, that remains to be addressed, is system security. While mobility facilitates the development of distributed health care systems and allows access for more potential users, it also leaves the system more vulnerable to malicious attacks.

6.1. Analysis of hypothesis

The hypothesis proposed in this paper are supported by the theory analysis. The main reasons that have led us to propose them are: The first reason is the need for optimization of resources in emergency departments of hospitals and health centers allowing cost reduction and increasing professional satisfaction. The second reason is the increase of mobile applications that has occurred in recent years in the field of health and more specifically those related to the professional field. The third reason is the automation of processes through the use of mobile devices that, in some cases were made of paper. Finally, the use of mobile devices to provide mobility of health professionals, changing and promoting the improvement of processes and less reliance on traditional work stations.

Furthermore, this study helps answering the following hypothesis: H1: The use of mobile triage tools facilitate the professionals work. H2: The set of tools and the use of mobile health techniques reduce costs. H3: The use of mobile tools improve process management.

Respecting research question H1 we have observed the use of mobile triage tools to facilitate the work of the clinicians and nurses, because this allows them to have more information to make a decision and, what is more important, to be able to monitor the patient at the time.

In the second research statement (H2) we have observed during the validation of the application that the use of this tool allows the professional to devote full attention to evaluate the patient, without having to be aware of evaluating other patients in the process. This improves their efficiency and reduce the response time in clinical situations.

The final research statement (H3) analyse the use of mobile tools to improve process management. This allows to optimize resources, facilitates the evaluation process by reducing the stress on clinicians and nurses, reducing the response time and the degree of satisfaction grows in patients and professionals.

7. CONCLUSIONS

In this study we have designed, developed and evaluated a technological tool based on triage, with the purpose of improving the process of triage in emergency areas.

Results suggest that the integration of emergency triage mobile application helps improving and optimizing resource management and decrease the response time.

Furthermore, mobile systems have great potential to transform the process, and possibly even the outcome, of the emergency triage.

The implemented system was subjected to a practical and technical evaluation by professionals, who also offered some feedback and suggestions about the system. The feedback from the caregivers showed that the proposed system can streamline and improve the process of triage.

This study shows that it is possible to develop this kind of technological solutions that work successfully as a patient evaluation tool, monitoring functions as blood pressure, vital signs among others. Therefore, mobile technologies can achieve a better healthcare and a better usage of health system resources.

Besides, medical apps used by health professionals can also demonstrate that it can improve quality of care and efficiency, as they are tools that help health professionals to avoid errors in prescribing or diagnosis.

Future research will consist in evaluating the pilot trial in designing an open and scalable monitoring platform that allows the direct incorporation of advanced modules based in multi-agent system that facilitates decision making.

The contribution of our work has focused on developing a system which is integrated with the systems of public health information through mobile devices, and allows the process of triage in the emergency department.

Likewise, an interface intuitive focussed on using touch screen was designed for the introduction and application management and patient information. This system provides healthcare workers with greater mobility and improved the process of evaluation.

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