Thailand Medical Mobile Application for Patients Triage Base on Criteria Based Dispatch Protocol

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Abstract

Background: Pre-hospital process is important criteria which helps patients in term of treatment performance before admitting to Emergency Department (ED) or requesting from an emergency unit. The existing system to triage patients in Thailand is not practically functioning in the primary medical or pre-hospital treatment in term of speeding, feature, or appropriate system. There is a high possibility for misrepresenting false Initial Dispatch Code (IDC), which causes the requirement of over or under emergency resources, such as rescuers and teams, community hospitals and emergency medical volunteers. Methods: In the development, usability system design has been applied to gather with system reliability test, to support the pre-hospital processes especially to sort patients by using IDC for requesting emergency resources. The development of triage mobile application has been conducted on both iOS and Android operating systems for supporting triage patient habits based on the CBD protocol. The 25 main symptom categories covered by CBD were used to design and develop the application, and 12 emergency medical staffs including doctors and nurses are subjected to test the system in the following aspects: triage protocol correction, triage reliability, usability and users' practical satisfaction. Results: The development result shows the comparison between the proposed triage application and staff experience. Triage reliability test implies that the time used to triage by experienced staffs, in many cases, is slower than using the application. For the usability test, the result shows that the application functions are more effective in terms of the increment of emergency operations and correction of IDC code represented. Conclusions: The triage application will be utilized to support the pre-hospital process and to classify patient habits before admitting patients to ED. The application can be suitable for user who are not medical emergency staff. Patients with non-trauma symptoms may be a suitable group to use the application in term of time used to identify IDC for their own symptoms. In term of using the application, it can possibly provide benefits to general people who want to self-identify their symptoms before requesting medical services.

Background

Recently, applying smart technology in daily life has been a common practice, especially in medical treatment. The smart technology nowadays provides faster computation, natural-command ability, wider presentation screens and applicably intelligent operation. (Emine, S., and Marco, S., 2009; Mohammad Mosa, A., et al., 2012; Yun Ahn, et al., 2016). It has been found that the advanced smart technology has also been widely used for medical healthcare purposes, for example, monitoring patients, tracing patient habits or patients' health conditions, consultation to an expert or doctor, obtaining suggestion on healthcare meditation and many more. (Thinnukool, O., et al., 2017; Nora, A., et al., 2018). The number of people who requires doctors consultation or to get medical service could decrease by substituting new technology as an alternative. Although the smart technology trend in healthcare around the world has been increasing and the duties of medical staff has been decreasing, inadequate public health support and services are still problematic in Thailand. An application of smart technology has been developed to help the overcrowding of emergency care unit, but the system does not solve all the problems in the unit operation.

According to the National Bureau of Statistics in 2018, there were 220 million of out-patient in Thailand, There were 35,388 doctor staffs and where 180,589 were service providers and hospital staffs (Ministry of

Public Health, 2018). From the numbers, Thai healthcare system should have a better system aiding primary care doctors. An ideal primary care system would include self-care system, long-distance patient care system, effective patient screening system and self-care knowledge providing channel which is important to help alleviate the public health unit workloads. The medical personnel, especially the primary care doctors could be effectively managed and patients can be forwarded in the correct order to fit with the available resources and medication using the technology. This is the key elements of the national strategic plan for public health in the 20 years following the Thai government policy of Thailand 4.0. (Suwankesawong, W., 2017).

However, the concerning limitation is the proportion between doctors and patients. The overcrowding problem in hospitals in Thailand is occurred due to many causes. For example, symptoms of the disease are sometimes difficult to predict. The side effects are sometime unclear and the illness caused by the accident would need a quick assessment. So, to save time in terms of decreasing the overcrowding in hospital, primary care physicians are very important factor for treatment and patient assessment in order to forward the patients to appropriate medical services either in the case of a normal illness or emergency in a timely manner (Suriyawongpaisal, P., et. al., 2014; Kaz,i B A., 2019).

Moreover, in many cases, the requesting of pre-hospital from rescue teams, rescuers, community hospitals and emergency medical volunteer are misrepresentation due to incorrect IDC or requiring over or under emergency resources. It has been reported by the national institute of emergency medicine of Thailand that 60% of patients who come to ER did not require any urgent treatment. This issue is similar to many regions when a patient needs an immediate care from medical providers due to lack of confident in primary care access. (Snooks, H. A., et. al., 2006; Coster, J E., et. al., 2017).

As the result, many patients are admitted to the emergency room and this causes the increase of overcrowding of the emergency care units of OPD and emergency rooms.

Thus, an effective patient assessment at the pre-hospital process can reduce the overcrowding problem in the hospitals. For example, in case of emergency the rescue teams, rescuers, community hospitals and emergency medical volunteer bear the responsibility to assess and analyze any suspicious symptoms of patient and requests an emergency resources. When these staffs do not have comprehensive health assessment field experience, the classification of patients by using CBD could be misrepresented due to incorrect IDC and leads to the requirement of over or under emergency resources.

The best way for correct assessment is to consult the provincial emergency command unit requesting a IDC by asking a CBD questions, which takes at least 2-3 minutes or more by phone. After a IDC is identified, the provincial emergency command unit will inform a hospital for medical resources to pick up the patient.

Trying to decrease time and increase performance of the pre-hospital process are still a challenging task for the National Institute for Emergency Medicine of Thailand (NIEM). Although the systematic patient assessment program developed by the NIEM has been used for patient assessment or to triage patients for IDC, it has been found that the program is somehow too difficult to use. A computer is required to run the program (Microsoft Access), which is not practical for primary emergency medical unit operation in nature.

For that reason, the system from NIEM is not applied except for the provincial emergency command units because they are the center emergency units.

Moreover, most Thai medical doctors use the medical application in term of practical operation of the application. There are also popular systems, such as the Canadian Triage mobile application, Mobile ESI, which are the standard for emergency medical service in Thailand. The application is widely used by medical doctors for patient triage which provides ease of use on smart mobile phones for referencing triage protocol. The result of the study informs that mobile application may have better benefit for staffs experienced in triage (Savamongkornkul, S., et. al., 2017).

However, the limitation of this application is that the system will only be effective for users with medical knowledge, as the application requires medical terminology usage. For the pre-hospital process, there are not only medical staffs, but volunteers who also handle the pre-hospital process.

The research question is what kind of system can provide patients triaging for requesting IDC and what is practical for real-life operation by rescue teams, rescuers, community hospitals and emergency medical volunteers.

Moreover, there are some statements to be concerned in order to develop the system such as how the system can help decreasing the overcrowding of ER, how the system can increase patients' knowledge when they are encountering suspicious symptoms, how would they know whether the encountered symptoms need any urgent treatment or not when they are at home.

Therefore, there should be a system that can help the primary care physicians or patients to perform illness screening for both normal and emergency cases. The system should also be able to provide a good referral to an appropriate emergency medical service. The application could also help patients to determine their own symptoms in many aspects such as symptoms severity evaluation and urgent treatment needs. The system should have a function to sort symptoms according to international standards.

Based on such problems, this research project aims to develop the functionally designed Thailand medical mobile application for patients triage base on criteria based dispatch protocol which can provide suitable use on mobile application systems. The application will serve as a tool for primary emergency medical practitioners and general users. In this study, a prototype will be developed using patients assessment data from the NIEM along with the analysis of the proposed model to reduce the limitations due to the user's specialized knowledge on the standard triage.

1.1 Triage Medical System

The use of technology on smart devices by health care professionals has transformed many aspects of clinical practices. Mobile technology including tablets have become commonplace in healthcare areas, leading to rapid growth in the development of medical software applications (apps) for these platforms. Mobile technology has played a huge role for users which includes, for example, offering them the information to track their health conditions, providing a suggestion on healthcare medication and being tools for medical providers for monitoring their patient (Deo, R C., 2015; Senders, J T., et. al., 2017).

Several benefits from healthcare system have been worthwhile for the secondary treatments in hospital or clinic. Additionally, using the system based on smartphones allowed an effective tracking or managing patients' health (Raybardhan, S., et. Al., 2005; Emine, S., and Marco, S., 2009; Mohammad Mosa, A S., Yoo, I., and Sheet, L., 2012; Thinnukool, O., et. al., 2017). In the content of application that associated to emergency case, many intensive researches have been conducted and we shall discuss about some of the works in this section.

Worldwide, incorporating information technology as smartphone into medical system have become conventional research and development in healthcare medical system due to its accuracy. For example, the study from Scott shows that the applied electronic triage provided more accuracy for triage protocol. The e-triage predictor and algorithm were applied and indicated probability of clinical care, emergency surgery, and hospitalization outcome to e-triage level (Scott, L., et. al., 2018).

Recently, Tadahiro developed the system for the emergency department operations. The prediction of ED disposition at triage remains challenging. The system approaches may enhance prediction and also improve the ability to predict disposition of patients as well and also support medical duties. (Tadahiro, G., et. al., 2018)

Lei and team work was aiming to use the triage to identify patients who require immediate resuscitation, to assign patients to a pre-designed patient care area, and to initiate diagnostic/therapeutic measures as appropriate. This study aimed to use emergency severity index (ESI) in a pediatric emergency room. The result found that the increasing performance of triage of nurses took approximately 2 minutes for triage. The results of triage made by nurses were similar to those made by doctors for ESI in levels 1-3 patients. This finding indicated that the nurses are able to identify severe pediatric cases. (Li, Wang, et. al., 2011)

Moreover, the development of triage mobile application especially in healthcare was applied to dental science. Corey, D. S., et, al., (2016) developed the mobile application system for the triaging dental emergency. The development research consisted of a need analysis and quality assessment of intraoral images captured. User can report habit themself by select or identify the most appropriate scenario that describes user discomfort and user were able to complete a report of triaging within 4 minutes. The application has helped the dentists and patients in term of self-triage prior to the dentist visit.

In Thailand, there is an application of medical system developed by Peradet, S., (2017), which can be used in tracking high-risk STROKE and STEMI patients who require services from Emergency Medical Services (EMS). The system can be operated on both Android and iOS operating systems together with GPS Tracker to provide the location of the transmitter at the current time. The use of GPS Tracker through GPS satellites and transmissions over the 3G mobile phone network are studied in this research. We focused on programming to integrate them with the system for semi-automatic usage. The program has been tested by focusing on the group of STROKE and STEMI patients who need emergency medical services at the scene in urban areas where mobile phone connection is accessible. This enable the system with revealing capability for accurate locations of emergent patient occurrences. For patient safety and emergency system optimization, emergency medical services can apply information technology to medical applications.

Ruangtananurak, R., (2014) has developed an emergency alert system including maps for positioning of emergency medical services. The patients or witnesses who encounter accidents can use the application on smart phone to send information from the scene, such as the accident location or other information, to notify the centers in the area. The information, along with the location of the scene, will be sent to the EMS. EMS unit can accurately locate the scene and the fastest route that allow emergency ambulances to get to the accident location quickly. It also includes directions to the nearest hospital.

As we can see from many examples, applying the system based on mobile application in triage is a suitable tool for identifying severe cases and then immediate interventions can be performed accordingly. However, the proposed system should also be able to help patients to determine their own symptoms in many aspects such as the symptoms description and their severity. Moreover, the mobile application should contain a function to sort symptoms based on Thai criteria based dispatch standards.

Methods

2.1 Thai Triage Standard

The triage is the process of determining the priority of patients' treatments based on the severity of their conditions such as emergency or normal. This help distributing patient treatment efficiently when resources are insufficient for all to be treated immediately. Triage may also be used for patients arriving at the emergency department, or telephoning medical advice systems (Iserson, K V., and Moskop, J C., 2007), and also reduced the subjectivity of the triage decision, and increased more accuracy for pre-hospital process National Institute for Emergency Medicine, 2011; Singer, R F., et. al., 2012; Jones, C. M., et. al., 2015).

In Thailand, criteria based dispatch has been used as the standard to identify IDC which is based on patient signs and symptoms collected by 25 main dispatcher’s category (National Institute for Emergency Medicine, 2011; Gilboy, N., et. Al., 2012). With the CBD protocols, there are questions for patient interview as a rapid identification tool of patient statuses that are unstable or "sick" (King County Emergency Medical Services Division, 2010). Five colors code identifies status of patients and requesting pre-hospital resources. The IDC is shown in Table 1 which indicates the details of triage criteria and the corresponding essential response of each color, whereas Table 2 shows numbers of 25 main symptom categories. Based on the CBD protocol, the result from patient interview will result an IDC. For example, a patient has been triaged by considering each criteria of the symptoms, the result will show the main symptom code, a color code and a triage criterion. If the result is “12 red 1”, it means critical emergency patients with cardiac arrest. Then, the emergency staff will request any emergency medical resources and operate following the corresponding essential response.

2.3 Software development process

Thailand medical mobile application for patients triage base on CBD was developed based on the concept of solving the problems of pre-hospital process mentioned earlier. The adapted waterfall methodology is one

kind of software development procedure that was applied as a guideline in 7 steps of the development process (Ivar, Jacobson, 2015).

Step 1 Software requirements: This step, the information analysis is incorporated and all of necessary information from emergency doctors, emergency staffs, and nurses was collected by interviewing to find what functions are necessary for triage patients.

Step 2 Analysis: The application development process considers usability in term of functionality, convenience, triage accuracy, and accessibility. And to identify functional requirements based on the software requirements in step 1, the application proposes, the benefits and the application use, as shown in the Table 3.

Step 3 Design: This step is considered as the process using analytic result to design application functions and graphic user interface. The functions will be designed by considering the practical use for the real operation. State diagram to describe behavior of the system in Figure 1 shows functional design which is corresponding to functional and graphical design in Table 3. Moreover, in this step, the application is designed as the requirements for the realization of user interface on mobile applications together with the navigation components, input controls, screen proportion design, menu list navigation and deep layout of the screen by using the human-centered theory, Eight Golden Rules of interface design and Nielsen's Ten Heuristics (Cooley, M., 1989; Nielsen, J., 1994).

Step 4 Development: In this step, the iconic framework, which is a nonnative language for mobile application development has been applied. This framework is suitable for both iOS and Android operating systems. Firebase has been employed for the user database including triage results, user information, and other information used in the application.

Step 5 Testing: Although the advanced functions of smartphone device play roles in term of usability, capacity of adapting, especially in medication mobile application, user's interaction, perception about places and objects are inputs that take participant between the system and users, especially for emergency cases. If there is any misplaced element, the result of the participant would be miscommunicated and then more operating time would be required. Thus, to inform that the application will perform well in term of time consideration, this step has to be tested in the scenario with staff capable for triage. Moreover, the IDC accuracy and question flow of triage have to be tested and compared to the flow of the CBC protocol, in which it was under the consideration of emergency voluntary staffs. Thus, in order to perform the application testing, three points of testing are illustrated in Table 4.

Step 6 Operations: This step is after the application has been verified as the correction of CBD to releases IDC by medical emergency doctors. The application will make a request for ethical approval before releasing the data to rescue teams, rescuers, community hospitals and emergency medical volunteer via Google play and App Store.

Results

3.1 Development of Mobile Application

The application was developed by using iconic framework. The compatibility, error, missing information, and quality of application development was evaluated. In the application development, the final version of the proposed application, which contains four mains function including triage, finding responsibility of emergency care unit, patient triage log file and export IDC information, has been released.

The application and functional test were performed by using iPhone 6s and Huawei Android phone. At the time of the study, the specifications of smartphones were defined as the application development is for medium and large screen display devices, due to the visibility consideration and appropriation to the medical application (Boissin, C., et. al., 2015).

The application procedure starts when user open the application, and then the screen A in Figure 2 will appear showing title and welcome graphics. After that, the main menu screen will be displayed. The buttons of the screen B supports the application login and triage history information, whereas the screen L on the right-hand side shows icons of the adjustment of 25 symptom symbols for triage which is demonstrated in table view (screen D) and list view (screen C), respectively.

In Figure 2, on the screens E-G, user can perform searching by typing the symptom name or keyword(s) into the textbox. User can select a symptom from the list of search result on the screen. Screen F shows steps for CBD questions. User has to click on his/her answer to get to the next question, then continue until the IDC is displayed as shown on the screen H or I. The screen I shows the triage screening result which identifies IDC code and the emergency status. The screen color will be the same as IDC code pattern. Suppose the IDC pattern is displayed in the form of “X color Y”, the first X refers to the group number of the symptom corresponding to the input information in Table 2 and the last Y refer to urgent status (1 being the highest and 9 being the lowest urgent status). On the screen K, the application provides information as a suggestion for user during waiting for emergency resources. Moreover, user can record the IDC code via the application for summarizing patient habits and urgent status for emergency doctors/staff which could be benefits of the suitable pre-hospital process. In addition, on the screen J, the application supports the task of exporting the details of patients/emergency cases in .pdf format which can be forwarded to other applications such as Line and SMS. On the screen M, the application also supports the task of finding the nearest emergency care unit and hospital locations as well as their contacts (phone numbers as shown on the screen N) sorted by the shortest distance and the shortest time to the destination. Furthermore, the direction map to the hospital is supported on the screen O with the overview information.

- **CBD questions flow assessment**

The CBD questions used in the application have been tested by evaluating the IDC result accuracy. All the 25 symptoms were tested in each question by following the flow in the CBD handbook. The emergency medical doctors tested the application by simulating a scenario and test the same scenario by using application compared to the handbook. From 2 scenarios of the first test, 4 mistakes of the CBD question flow were found. These errors have to be corrected before conducting another testing.

- **Triage time evaluation**

In this section, the application was tested to evaluate the reliability comparison between emergency staffs and the proposed application in testing scenarios. To do this, we performed sampling by drawing 2 symptoms from 25 symptoms, which are trauma and non-trauma symptoms to set as the simulation scenarios with some fictional characters for mocking up 2 suspected patient habits for the scenarios.

After explaining the patient habits, we recorded the IDC result and the triage time that emergency staff spent to obtain the IDC, then, compare the results between 3 conditions, including 1) using the application, 2) following the CBD protocol from the handbook and 3) relying on the emergency medical staff experience. There were 4 emergency medical staffs to be the pilot samples for testing triage.

Table 5 demonstrates the testing results of each condition with each scenario. The result shows clearly that using application for triage was as fast as the operation time from experienced emergency staff and as accurate as following the CBD protocol from the handbook. Some IDC misrepresentations were found when performing triage by relying on the staff experience.

In order to confirm the triage time testing, we conducted another test. In this test we compared the results between 2 conditions, the first condition is by using the application and the second condition is by relying on the emergency staff experience. Please note that the triage condition evaluation using the hand book was omitted in this test. Handbook referencing is only for the reliability testing. Using the handbook is not a practical process in the real operation.

The test conditions were set as following. The test samples were emergency medical staff, where each of the emergency medical staff has no more than 5 years of work experience. Then, we grouped them into 3 people per group for triage by both using the application and relying on their experience. Test cases are from sampling 13 scenarios out of 20 scenarios, which covered 25 main symptom categories (See in Table 2). Then, the average triage operational time of 3 people will be calculated. The result of the triage time testing is shown in Figure 3. The result shows that using the application to triage in the trauma symptom cases spent less time than relying on staff experience only in the case of the non-trauma symptoms, while for the case of trauma symptoms, using staff experience took less time than using the application.

- **Application usability test**

Usability test is a very important point of the study. The medical mobile application for patients triage needed to be tested, because practical and pertinent considerations are the pain points of the previous system. Thus, this step is required to ensure the quality and reliability of the application. The steps to develop a high quality medical system and to make the software reliable are focused. The usability test criteria from the usability testing technique conducted by Jakob Nielsen was adopted and applied in this experiment.

To do this, a scenario was set to evaluate usability. The key points of testing are occurrence of difficulties, doubt visual representation, doubt on usage, missing information, and misunderstanding when using the application. Each of the functions of the application was tested by 12 emergency medical staffs including

doctors and nurses. The testing result in Table 6 shows the comparison of the frequency of finding in each criteria (user motivation) and the application functionality.

There were 12 times of misunderstandings the triage function (ranking the 2nd in operational errors). The missing information were found when users wanted to repeat answering the CBD questions, which leaded to the duplicated IDC of patient habits in the log file. Doubt visual representation was found when user did not read the information showing on the left-side of the previous answer. There were some difficulties finding the answers of the pervious CBD questions. The second function, finding responsibility of emergency care unit, was found missing 4 times with the 3rd overall ranking in operational errors. This might be due to when the application shows the list of available emergency care provider locations via the navigation applications such as Google map, some errors arising from navigation applications are also possible. The next function is patient triage log file, which was tested with 3 times of doubt on usage and misunderstanding. It was found that user did not understand why they have to resist the application. Logging file operated as history triage information record to confirm the patient habits. The last function is exporting IDC information to other applications such as SMS, Line, WeChat, e-mail, etc. The test result was found the first ranking of all evaluations with 3 times of usability difficulties as the users encountered the problem sending information while the devices did not connect to the internet. While misunderstanding of using the function were found 4 times because the users assume that this function is used for medical report.

For all of the evaluations of user motivation, the misunderstanding was found in the 1st ranking with the total of 13 times. The 2nd ranking of the evaluations was doubt on usage, which occurred in the patient triage log file and when exporting IDC information. The 3rd ranking of the evaluations was doubt visual representation on some graphics and figures in the application in the triage function, the finding responsibility of emergency care unit function, and the exporting IDC information function, respectively.

Discussion

This study has been conducted following the research questions: what should be in the system that can help the primary care physician group or the patients to perform illness screening in both normal and emergency cases and how to design and develop an application to be able to help patients to determine their own symptoms in many aspects such as the symptoms interpretation and do they need any emergent treatment.

Based on the application analysis and literature review from the previous studies of server medical application systems, the emergency alert system, map positioning for emergency medical services, patient monitoring and tracking system for high-risk patients who require services from Emergency Medical Services (EMS) (Ruangtananurak, T., 2014; Sumrumeram, S., 2017; Senders, J.T., et. al., 2017; Scott Levin, et. al., 2018) and dental application triage development (Corey, D. S., et. al., 2016), are the systems that can be used to support the medical emergency operations. Thus, the proposed system has been designed for Thai social context. The application may be operated on the same duties as other applications in helping patients and can also provide suggestions as an alternative choice for emergency aid.

In the process of application development, the application for patients triage was developed by following the Criteria Based Dispatch Protocol to request IDC code in pre-hospital process (King County Emergency Medical Services Division, 2010; National Institute for Emergency Medicine, 2011; Gilboy, N., et. al., 2012). The application can serve as a tool for primary emergency medical practitioners and general users. The adapted waterfall methodology together with the Ionic framework have been employed to produce the system under Android and iOS operating systems (Davis, B., 2012; Jacobson, I., 2015). The human-centered theory, Eight Golden Rules of user interface design and Nielsen's Ten were employed to design proper user interface of the application (Nielsen, J., 1994; Cooley, Mike., 1989) for practical used in real emergency situation.

The 25 main symptom categories covered by CBD were used to design and develop the application, and 12 emergency medical staffs including doctors and nurses are subjected to test the system in the following aspects: triage protocol correction, triage reliability, usability and users' practical satisfaction.

As a result of the application development, 4 functions were developed including (1) the triage function to identify IDC, (2) the finding responsibility of emergency care unit function, (3) the patient triage log file function to provide the triage information to inform the pre-hospital process and confirm triage information and (4) exporting IDC information function for sending obtained IDC to the provincial emergency care units which can use that information for preparing emergency resources when patient is being transferred.

The first application testing result was performed to check triage reliability and time spent in performing triage under different conditions. The first experiment was to set the scenario test comparison for triage time testing. The result shows that, in the case of non-trauma patients, using the application can help reduce triage operational time when comparing to the emergency staff triage. However, using experienced staffs to identify IDC consumed less time than using the application in the case of trauma patients. The accuracy of identifying IDC under the condition of using handbook and the application is similar.

The second testing was performed by sampling 13 scenario test cases from 20 scenarios. The case of trauma patients, the experienced staff required less time to triage than the application, however, the triage may result in misrepresentation of IDC. The majority of result can be claimed that the application is useful in terms of operational time and reliability considerations. Using the application is more likely suitable for non-trauma patients. However, the study of Savamongkornkul, S., et. al., (2017) indicated that mobile application performance could be enhanced when operated by experienced staffs in triage.

The second testing result was conducted as in section 3.4, the application usability test. The testing criteria was applied from the human-centered theory, Eight Golden Rules and Nielsen's Ten Heuristics (Cooley, Mike, 1989, Nielsen, J., 1994). The result shows that the application still shows weak points with some misunderstanding when in use. Triage function is the first ranking of the weak points. In this function, users need to answer numbers of CBD questions, misunderstanding of users came from the number of answers needed.

In fact, some questions required only 1 or 2 answers. As the result, misunderstanding of users is the cause. It was also found that missing information of finding responsibility of emergency care unit function is caused

from the Google API locating incorrect locations that are not emergency care units. Thus, Google API usage needed to be amended in order to locate the correct information of locations.

The application testing still shows weak points due to user perception, however, this application can be used to correctly perform symptoms self-assessment, including in case of emergency. This will make the whole treatment more effective.

This project can result in the overall development of primary care medical team to gain more knowledge by using this application. The benefits and research utilization can be generated as improved primary medical emergency staffs' knowledge and performance base on accuracy of triage standard. The patients who apply the triage mobile application for primary diagnosis can decrease an overcrowded hospital center in each Northern Province. The result concomitantly supporting the result of Savamongkornkul, S., et. al., (2017) mentioned earlier.. And if the application can be a tool for user to triage themselves when experiencing a suspicious symptom, it can help ED to reduce service time and increase quality of medical service as reported by Kazi. B A., (2019) that service time is related to patient outcome. Thus, the application is much suitable for people who requesting CBD code without comprehensive medical knowledge and skills.

Conclusions

Based on the pain points of the National Institute of Emergency Medicine of Thailand' system, the new proposed system was developed. The Thai medical mobile application for patients triage based on Criteria Based Dispatch (CBD) has been released as the first mobile application for triage in Thailand to support the pre-hospital process, especially in patients triage using IDC for requesting an emergency resources. The application development employed the usability system design and system reliability test, which are considered an appropriate design for Thai social context.

The application test confirmed that the majority of testing result is useful in term of operational time and reliability considerations. Using the application is more likely to be suitable for non-trauma patients rather than trauma patients.

Thus, using the application can be used as a practical tool that is also suitable for a learning tool for new emergency staffs who do not have adequate skills in the medical emergency field.

In summary, the Thailand medical mobile application for patients triage is an application of smart technology which can provide benefits to users as a tool for rapid triage screening, educating patients and new emergency staff and a preventing tool for overcrowding problem in emergency care units in Thai hospitals.

Abbreviations

ED: Emergency department

CBD: Criteria base dispatch

EMD: Emergency medical dispatch

IDC: Initial dispatch code

ESI: Emergency severity index

EMS: Emergency medical services

NIEM: National institute for emergency medicine of Thailand

BLS: Basic life support unit

ALS: Advance life support unit

FR: First response unit

GPS: Global positioning system

API: Application programming interface

Declarations

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Authors' contributions

Assistant Professor Krongkarn Sutham, MD and Nantanan Jengserbsan, MD had a substantial contribution to conception and triage criteria flow design. Assistant Professor Dr. Orawit Thinnukool substantial contribution to the study design, analysis, and interpretation of the findings, Dr.Pattaraporn Khuwuthyakorn obtained research operation and data preparation.

Ethics approval and consent to participate

Ethical clearance and approval were obtained from the, Chiang Mai University research ethic committee with exemption (Ref. No. 2562/078). The data confidentiality of information was maintained anonymously. Moreover, informed consent was employed to respondents by explaining the purpose of the study as well as maintaining the subjects' confidentiality.

Consent for publication

This paper

Competing interests

All authors declared that they have no competing interests.

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Tables

Table 1: The explanation of Initial Dispatch Codes

Colors	Triage Criteria	Essential Response
Red	Critical emergency patients	Responsible to pateint with Basic Life Support Unit: (BLS) within 4 mins after accident then responsible to pateint with Advance Life Support unit (ALS) within 8 mins after accident.
Yellow	Urgent emergency patients	Responsible to pateint with Basic Life Support Unit: (BLS) within 8 mins after accident then responsible to pateint with First Response Unit (FR) within 15 mins after accident
Green	Not urgent emergency patients	Responsible to pateint with Basic Life Support Unit: (BLS) within 8 mins after accident.
White	General patients	Responsible to pateint via telephone referral program and consider to Basic Life Support Unit: (BLS)
Black	Not patients	No responsible to pateint

Table 2: The 25 main of symptom categories

Code	Symptom	Code	symptom
1	Abdominal/Back/Groin Pain	14	O.D./Poisoning
2	Anaphylaxis/Allergic Reaction	15	Pregnancy/Childbirth/Gyn.
3	Infectious Disease	16	Seizures
4	Bleeding (Non-traumatic)	17	Sick (Unknown)/Other
5	Breathing Difficulty	18	Stroke (CVA)
6	Cardiac Arrest	19	Unconscious/Unresponsive/ Syncope
7	Chest Pain/Discomfort/Heart Problems	20	Pediatric Emergencies
8	Choking	21	Assault/Trauma
9	Diabetic	22	Burns - Thermal/Electrical/Chemical
10	Environmental/Toxic Exposure	23	Drowning/Near Drowning/Diving or Water-related Injury
11	--Not define symptom--	24	Falls/Accidents/Pain
12	Head/Neck	25	Motor Vehicle Accident (MVA)
13	Mental/Emotional/Psychological	-	-

Table 3. Functionalities of the Triage mobile application

Function	Propose	How to use	Benefits	Graphical design
1.Triage	To identify IDC	Interview patient or consider patient habit by following the questions of CBD in application question by question. The result will show IDC to requesting a pre-hospital resources.	IDC can scope an appropriate requesting to pre-hospital resources. The IDC together with part of suggestion where patient waiting in pre-hospital should be transferred.	Point of design: 1) quickly accessible to triage 2) triage accuracy presentation 3) quickly accessible to a suggestion 4) direct manipulation for easy remembering 5) menu selection replace keyboard using
2.Finding responsibility of emergency care unit	To show nearby emergency care unit and a phone number	This function show emergency care unit based on Google map API with shortest transferring time consideration.	Patient or staff will have an information of emergency care unit which was ordered by transferring time from current location.	Point of design: 1) quickly accessible 2) accessible timing 3) menu selection replace keyboard using 4) reduce short term memory load

Table 4: Points of consideration for the application testing

Testing Criteria	Proposes	Methods
1. CBD questions flow	- Correct or incorrect IDC in each symptom	- 25 symptoms were tested and compared with step by step of CBD question -Testing by comparing with CBD handbook case by case which checked by medical emergency doctor
2. Triage time	- Time of testing for using application, open handbook and emergency medical staff.	-Testing by comparing with simulated scenario and comparison time for using application, open handbook and emergency medical staff
3. Application usability test	- Consider as user friendly and practical uses in real operation	- Evaluating by 10 emergency staffs who were selected as a sample group. Application testing and questionnaire were used. - Nielsen's ten usability heuristics mixed with the human-centered theory, and Eight Golden Rules of interface design were used for testing for application performance in term of usability and user friendliness.

Table 5: Scenario test comparison for triage time testing and triage result

Patient habits	Application	Open Handbook	Experienced staff
Scenario 1 : **Environmental/Toxic Exposure** 1) conscious or breathing 2) unable to speak normally (work of breathing)	5 seconds IDC :14 Red 2 Critical Patient	13 seconds IDC :14 Red 2 Critical Patient	4 seconds IDC :14 Red 1 Critical Patient
Scenario 2: **Environmental/Toxic Exposure** 1) conscious or breathing 2) no asthma 3) breathe fast 4) age <20	8 seconds IDC :14 Red 2 Critical Patient	14 seconds IDC :14 Red 2 Critical Patient	6 seconds IDC :14 Red 2 Critical Patient
Scenario 3: **Anaphylaxis/Allergic Reaction** 1) conscious 2) breathing 3) speak normally 4) fainting 5) drug allergic	20 seconds IDC : 2 Yellow 4 Urgent Patient	28 seconds IDC : 2 Yellow 4 Urgent Patient	15 seconds IDC : 2 White 2 General Patient
Scenario 4: **Anaphylaxis/Allergic Reaction** 1) unconscious 2) responding to other 3) breathe fast 3) speak normally 4) asthma 5) age <20	15 seconds IDC : 2 Red 2 Critical Patient	18 seconds IDC : 2 Red 2 Critical Patient	10 seconds IDC : 2 Yellow 8 Urgent Patient

Table 6 Cross matrix usability test result

	User Motivation							
Function Test		Usability difficulties	Bug founding	Doubt visual representation	Doubt on usage	Missing information	Misunderstand	**Total**
	1. Triage	1	0	3	2	0	6	12(2)
	2. Finding responsibility of emergency care unit	2	0	2	0	4	1	8(3)
	3. Patient triage log file	0	0	1	3	0	3	7
	4. Exporting IDC information	3	0	2	3	0	4	13(1)
	Total	6	0	7(3)	8(2)	4	13(1)	22

Figures

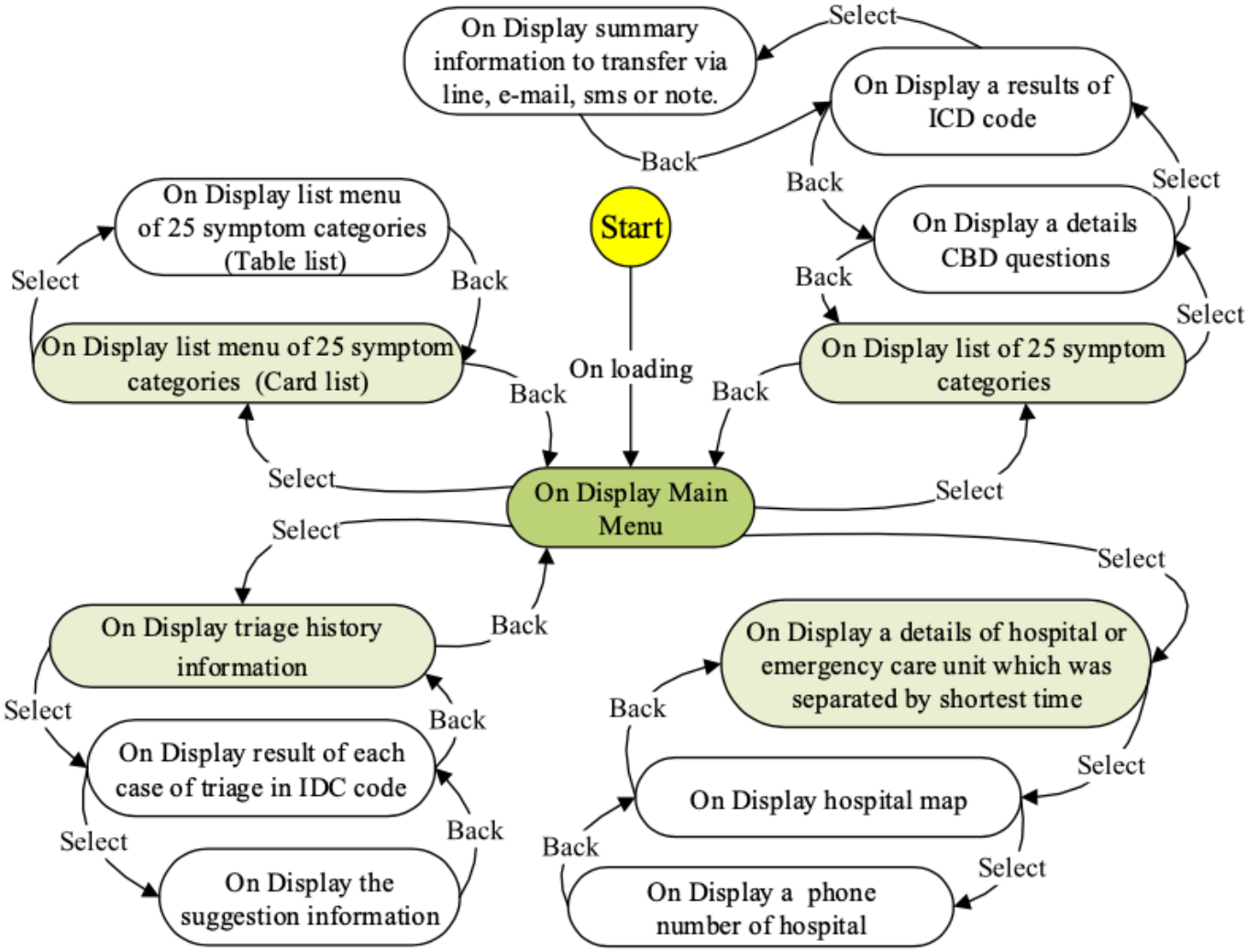

Figure 1

State diagram shows the functional design of application which is corresponding to functional and graphical design based on the user requirement in Table 3.

Figure 2

Graphic user interface of Triagist mobile application

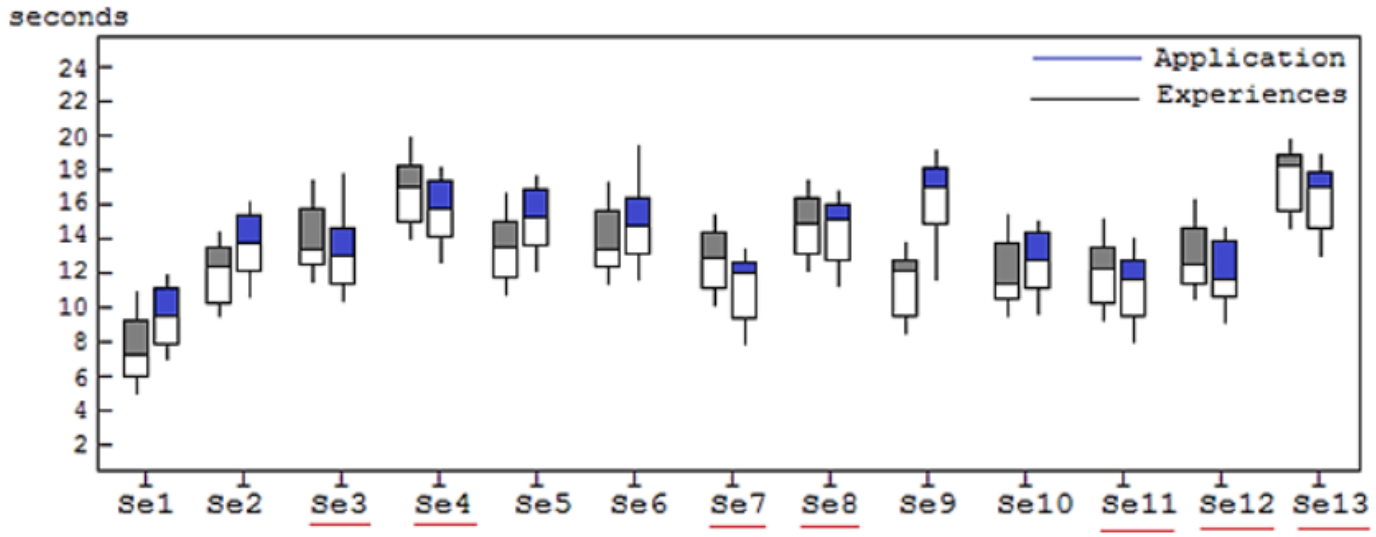

Figure 3

Scenario test comparison for triage time testing and triage result. The red-underlined scenario represented the non-trauma symptoms.