M-Health: A Mobile Application For Monitoring Acute Respiratory Diseases (ARDs)

Vatcharaporn Esichaikul

Ratchadaporn Rermlawan

Clemens Bechter

M-HEALTH: A MOBILE APPLICATION FOR MONITORING ACUTE RESPIRATORY DISEASES (ARDs)

Vatcharaporn Esichaikul, Asian Institute of Technology, vatchara@ait.ac.th
Ratchadaporn Rermlawan, Queen Sirikit Hospital, ratchadaporn.r@navy.mi.th
Clemens Bechter, Thammasat Business School, bechter@gmail.com

ABSTRACT

One of the most widespread epidemics is ARDs. Because of a limited number of hospital beds and hospital staff, hospitals cannot provide sufficient service and support to large numbers of suspected ARD patients. Many patients who are suspected of having acquired ARD have normal vital signs and can be transferred to home care service. Due to the possible incidences of deaths, this paper is aimed to propose a suspected ARD patient monitoring and controlling system by using mobile technology to remotely monitor home care patients with suspected ARD in order to reduce the difficulties of caring for these patients.

Keywords: Mobile application, Acute Respiratory Diseases, Mobile-based monitoring and controlling system, Infectious disease monitoring, Home care monitoring.

INTRODUCTION

Acute Respiratory Diseases (ARDs) are group of diseases which their route of transmission is airborne and droplet transmission. Epidemics and pandemics of ARDs (e.g. bird flu and AH1N1 flu) have widely spread to world populations, thus the monitoring and controlling of epidemic of ARDs are required [7] [8] [10]. ARD symptoms include fever, cough, sore throat, coryza, shortness of breath, and wheezing or difficulty in breathing [11] [12] [13]. Because ARDs symptoms are almost like the symptoms of general respiratory tract infection and influenza, high risk patients and patients with the ARDs criteria were considered to admit only.

Actually, people who are contaminated with pathogen caused ARD can be categorized to two groups: ARDs patient and suspected ARDs patient. In epidemic period, there were two difficulties to support contaminated patients: limited hospital beds and insufficient hospital staff. Thus, patients who have the early symptoms of ARDs or suspected in ARD have transferred to home care service because patients in this group have a normal vital sign. The current monitoring and control in the period of ARDs epidemic focus on patients who were admitted in the hospitals. Home care patients with suspected ARD cannot make a decision when they should visit hospital; it lead to the incidents of death of

ARDs patient who had the criteria symptom ARDs at home. Although every country implements public health practices, all these practices are often not enough to monitor and control an epidemic. For this to be successful, many countries apply technology to healthcare with the aim to monitor and control epidemics by distributing to their populations health knowledge related to epidemics. The two main technologies currently used to provide health services for people are electronic-based and mobile-based applications.

To apply technologies into health services, health websites have been created to provide knowledge related to epidemics. People can search for more information to prevent and protect themselves from the spread of epidemics. In addition, health applications are created to collect patients' information, predict, and locate epidemics. However, a geographic gap and a socioeconomic gap have been identified in the use of electronic-based applications and health websites. Many low-income people do not have their own computers and electricity services do not cover remote areas. Because of these two gaps, inequitable access to health services remains a problem.

With the development of communication technology, mobile technology can be applied in the healthcare system. Many projects related to epidemics have been produced and implemented in numerous countries, especially in the developing world. However, there are only a few mobile applications to monitor and control epidemics because it is a more complex application than surveying and providing knowledge. The widespread ARD epidemics and the deaths of ARD patients from severe symptoms are because existing systems do not provide rapid detection of ARDs. Therefore, the development of a new mobile application to support early detection in ARDs is required. The main objective of this study is to apply mobile technology to monitor and control ARDs patients at home by: 1) identifying the suitable pattern to monitor and control suspected ARD patients at home; 2) identifying the suitable mobile application development tool to develop a mobile application to monitor and control suspected ARD patients; and 3) developing a mobile application to monitor and control suspected ARD patients.

Esichaikul, Rermlawan, and Becther

LITERATURE REVIEW

This study reviews the epidemic control in ARDs including mobile technology and tools used to monitor and control ARDs. WHO [27] defines ARDs as "upper or lower respiration tract illnesses, usually infectious in etiology, which can result in a spectrum of illnesses ranging from asymptomatic or mild infection to severe and fatal disease, depending on the causative pathogen, environmental, and host factors". There are many pathogen caused ARDs such as H5N1, AH1N1, and Streptococcus. The route of transmission of ARDs is airborne and droplet, thus this group of diseases can be developed from endemic to epidemic or pandemic quickly after its spread. The symptoms of ARDs include fever, cough, wheezing, and difficulty in breathing and the initial treatment of ARDs is based on patients' symptoms. Specific treatments are used after physicians have recognized the results of blood tests or nasal swab test for pathogen culture. Vaccinations have been produced and used for prevention, but only after an epidemic has spread. The standard management for suspected H1N1 and H1N1 patients was introduced by WHO [28] for the last H1N1 epidemic in 2009. The algorithm used to manage patients with suspected ARD based on hospital treatment capability. When ARDs contaminated patients visit a hospital, they were treated based on patient's symptoms. Contaminated patients who have high risk for complication (for example, patients with chronic cardiovascular diseases, chronic broncho-pulmonary diseases, pregnant women, over 65 years old and younger than five years old), and contaminated patients who have severe symptoms of ARDs are considered to admitted in hospital and treated with anti-viral drug [21] [26]. However, many contaminated patients are diagnosed as suspected ARDs or the diseases related to respiratory tract infection, such as phalyngitis, influenza, and upper respiratory tract infection have transferred to home care service [2] [9] [15]. They had to take care themselves at home.

There were many mobile applications introduced in healthcare services based on five application types: health education awareness, remote data collection, remote monitoring, communication and training for healthcare workers, and diagnostic and treatment support [24]. A mobile application for remote monitoring is applied to monitor high distant home care patient such as a chronic patient with stable symptom. There were several applications developed to remotely monitor patients. A summary of features and functions of mobile health applications in remote monitoring category is shown in Table 1. Only SIMpill Solution for TB provides the decision support function. However, its function suggests

the simple method to resolve the problem in patients who forget to take meditation. The Mobile Care Support and Treatment Manager (MCST) application provides two types of usage, namely, group and individual, and the former allows group members to share their care experiences with each other. Most mobile health applications [20] for remote monitoring use a PDA as the mobile device and applications installed for individual usage. Most servers have operating systems compatible with a mobile device platform; this allows mobile applications to work as dependent platforms. Therefore, people who want to use the system need to have a mobile device with a compatible operating system to run an application.

Table 1: A comparison of mobile health applications for remote monitoring

| Features & Functions Application Name	Report	Security	Alert System
Cell-Life (created for health workers) [3] [4] (www.cell-life.org)	text	Yes	no
Chinese Aged Diabetic Assistant (CADA) [5] (www.cadaproject.com)	no	Yes	no
Colecta-PALM for HIV treatment support [6] (http://colectapalm.org)	no	Yes	no
Mashavu: Networked Health Solutions for the Developing World [14] (/www.ideablob.com/ideas/1528-Mashavu-Networked-Health-Solu)	no	yes (physician)	no
Mobile Care, Support and Treatment Manager (MCST) [18] //www.freedomhivaids.in/mCST.htm)	text	Yes	yes (alarm setting)
SIMpill Solution for TB [22] (www.SIMpill.co.uk)	graphic	No	yes (massage)
Virtual Health Pet [23] (www.tridedalo.com.br/fabiane/index.htm)	no	No	yes

Mobile technology has become an important technology to provide convenient communication especially in remote areas. Mobile technology consists of three main components, which are wireless network technologies, mobile devices, and mobile application development tools. The development of each component has to support the other. There were many wireless network technology developed and each type of wireless network technology provides the different speed and range of coverage. Applying wireless network technology to health projects, project managers have to consider the issue for mobile health, such as security, bandwidth, and supported device. Notebook PC, handheld PC, and smart phones are the favorite devices used in the mobile health

Esichaikul, Rermlawan, and Becther

projects.

In summary, there are two main elements that directly affect the development of mobile applications to support the remote monitoring and controlling of epidemics in patients with ARDs. They are domain knowledge in epidemic control and development of technology. All population groups have the same opportunity to contact an ARD because it is caused by a pathogen that spread in the air and in shared areas in public places. An effective mobile application should support various mobile device platforms. In addition, any mobile application to be used to monitor and control patients with suspected ARDs should help users to early detect the ARD before patients become severely sick with ARD symptoms.

SYSTEM ANALYSIS

The system consists of five elements to support the remote monitoring and controlling of ARD suspected patients (see Figure 1). Firstly, a mobile web application server is utilized to manage all system functions and to generate the suitable markup language for each mobile device after a WAP or HTTP request is received. Secondly, a wireless network infrastructure is used as the communication media between mobile devices and servers. Thirdly, a system database is used to store data from both users (hospital staff and ARD suspected patients) based on a database schema. For the fourth element of support, the hospital staff use PCs or laptops to access the system for checking their patients' progressive symptoms, and lastly, ARD suspected patients use a mobile device to access the system to monitor and control their symptoms.
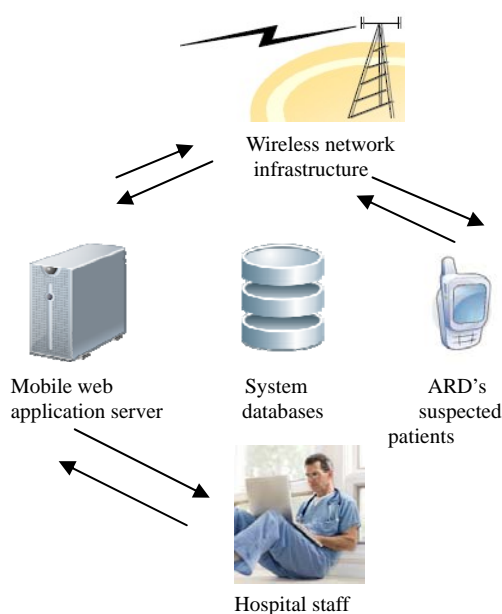
Figure 1 System architecture

Case Study: The Royal Thai Marine Corp Healthcare Unit

The Royal Thai Marine Corp Healthcare Unit is located in The Royal Thai Marine Corp in Chonburi Province, Thailand which provides the services of a primary hospital. It has one physician and 23 nurses who take care of The Royal Thai Marine Corp personnel and it provides 100 hospital beds to support its patients. To control the most recent ARD epidemic (H1N1 flu), this healthcare unit provides a screening room to investigate patients who have the influenza-like symptoms. Moreover, all hospital beds in this healthcare unit are for influenza-like symptoms only. Patients who have other diseases or symptoms that require admission are directly referred to H.M. Queen Sirikit Hospital after being investigated by hospital staff. A Royal Thai Marine Corp Healthcare Unit report (2009), states that in the period of the H1N1 epidemic situation (June - September 2009), 326 patients visited this healthcare unit and every day new cases were admitted. The infectious control guidelines, which are used in this healthcare unit, are based on the guidelines for infectious control for ARDs.

The Royal Thai Marine Corp Healthcare Unit has two work shifts: office hours (8.00 to 16.00) and after hours (16.00 to 8.00 the following day). A physician and two nurses are on standby to take care of patients during the office hours but only two nurses are on standby to take care of patients after hours. In the H1N1 epidemic period, all patients who were diagnosed with a common cold, influenza, pharyngitis, tonsillitis, unidentified cause of fever, and upper respiratory tract infection were admitted for observation of ARD symptoms [19]. These patients were observed for fever for seven days and if they did not have a fever (body temperature lower than 37.5°C) they were discharged. If their fever was equal to or more than 38.5°C for three consecutive days, they were diagnosed and treated as ARD patients. Following this, the hospital staff immediately referred all ARD patients to the infectious control unit of H.M. Queen Sirikit Hospital for proper treatment.

System Requirements

The system works as a medical application, thus the two requirements are required: domain knowledge requirement and users' requirement. These requirements are used to create functions for monitoring and control home care patients with suspected ARD.

Firstly, the domain knowledge requirement was gathered from interviewing three experts including an infectious control consultant, a home visit nurse, and a supervisor nurse. An infectious control expert recommends that the

Esichaikul, Rermlawan, and Becther

Ministry of Public Health of Thailand's pattern and investigation form be used to monitor and control suspected ARD patients at home. The expert also suggests requirements for infection prevention and control of epidemic and pandemic-prone acute respiratory diseases in health care created by WHO in 2007, to control suspected ARD patient's environment. From interviews conducted in this study, a home-visit nurse recommends that the hospital staff empower home care patients to check and record their basic vital signs (including body temperature, pulse, and respiratory rate recordings). A supervisor nurse suggests that suspected ARD patients should record their body temperature and other symptoms related to ARD twice a day: in the morning and in the evening. The pattern used to monitor and control suspected ARD patients in the novel system is summarized as a flow chart in Figure 2.
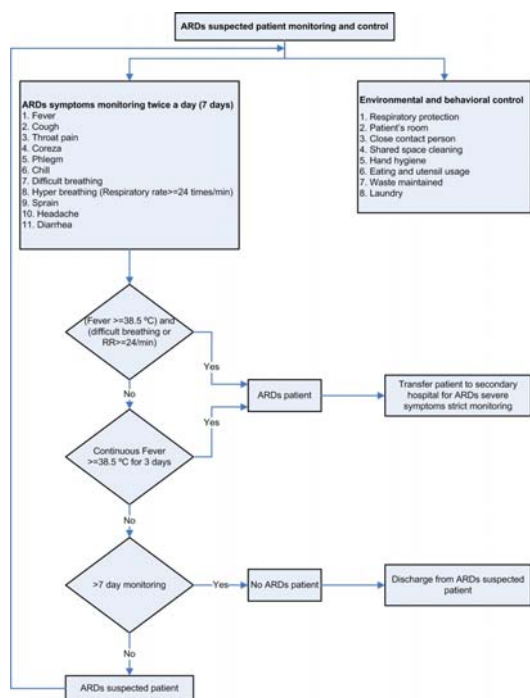
Figure 2 Pattern for monitoring and controlling suspected ARD patients in the system

Secondly, there are two main groups of users who access to the system which are hospital staff (include physicians and nurses) and patients. The requirements of each group of users are listed in the following.

1. *Hospital staff*
    a. Early detection by displaying an alarm message when patients' symptoms get worse in ARD criteria
    b. Display knowledge related to ARDs infection
   c. Track patients' symptoms and medication records

d. Report patients' symptoms and medication in individuals and groups of patients
    e. Recommend symptom-based nursing care.
2. *Patients*
    a. Direct contact to hospital staff via a mobile phone
    b. User identification to secure patient information
    c. Support various mobile device platforms.

Data Requirement

This system is directly linked to a hospital information system (HIS), therefore patients' personal data and hospital staff personal data are retrieved from the HIS database. The username and password of each patient is added to HIS to access hospital's online services. The necessary data used to monitor and control suspected ARD patients can be categorized into four groups: hospital staff profile, ARDs suspected patient profile, monitoring and controlling profile, and environment profile.

SYSTEM DESIGN

This study applied rule-based decision support model into the system. This system operates as a decision support system for patients as it provides automatic information support based on a suspected ARD monitoring and controlling pattern. This system consists of 32 rules for making decisions for each patient. Figure 3 shows the decision support rules to create this system.
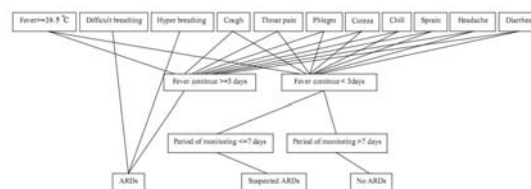
Figure 3 Rule-based decision support in the system

In this phase, this study designs a new system for monitoring and controlling suspected ARD patients at home by using mobile devices through a wireless network connection. The processes of the system are shown in Figure 4. This system is designed by using the Object-Oriented System Analysis and Design based on user requirements. The system use-case diagram, system class diagram, system sequence diagram, activity diagram, and deployment diagram are used to describe the system.

The ARD monitoring and controlling system is a mobile web-based technology and ASP.NET programming language is predominately used to develop this mobile health application [1] [16] [17] [25]. The database management system used in the system is SQL server. There are two

methods for users to access the system depending on the device type: a pocket PC and a mobile phone. The deployment diagram of the system is shown in Figure 5.

The system supports two groups of users: hospital staff (laptop/PC user) and patient (mobile phone user), thus two guidelines are applied to design the user interfaces. The Web Content Accessibility Guidelines (WCAG) 2.0 is used as the guideline to design the user interface of the web application to run on a PC or laptop. The Mobile Web Best Practices 1.0 is the guideline used to design user interfaces of mobile web applications to run on mobile phones.
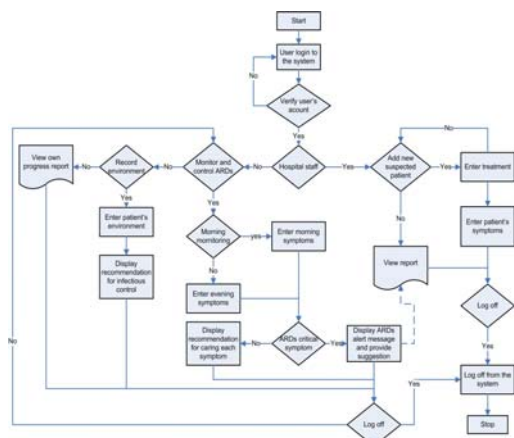

Figure 4 System flow chart of ARDs suspected patients monitoring and control system
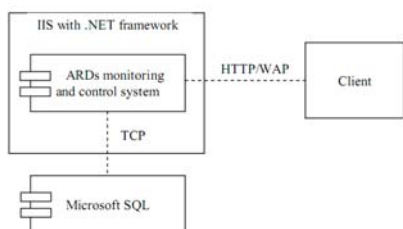

Figure 5 The deployment design of the system

After the hospital staff passed the user verification process, the system categorizes users into two groups: physician and nurse. Each user can operate in the authenticated functions only. A physician is responsible for adding treatments for a new suspected ARD patient (see Figure 6). For a nurse, he/she is responsible for adding information related to monitoring and controlling patient with suspected ARD before patients monitor themselves at home (see Figure 7). Moreover, the system provides two main reports for the hospital staff which are individual and group reports. There are four types of group report in the system: No ARDs, Suspected ARDs, ARDs, and the overall patient status. Figure 8 shows a report of the overall patients which the system calculates in real time. In addition, the system also provides the report to show real-time trend of ARDs of patients in the system (Figure 9).

For mobile users, the system provides three options for a patient after he/she passed the verification process. A patient can record daily symptom, record environment, and view own symptoms summary report. The system will display an alert message when patient's symptom is in the ARDs criteria, or recommendation for caring of each symptom message if patient is still in the suspected ARDs status. The system also displays a recovered ARDs message when a patient was monitored more than seven days without ARDs criteria. Infectious control for patients, a patient has to record patient's environment. If patient lives in the incorrect environment for controlling ARDs spreading, the system will display a message suggesting the suitable environment for home care patient with suspected ARD. The examples of mobile user interfaces for patient are shown in the Figure 10.
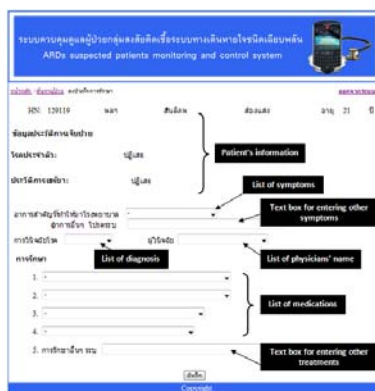

Figure 6 Entering a treatment page for physician

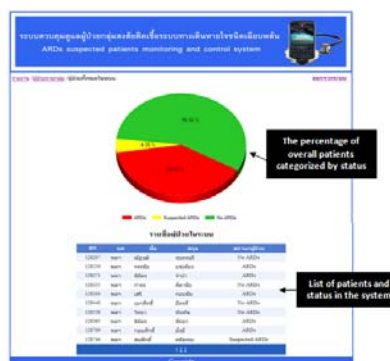**Figure 7** Entering ARDs monitoring Information page for nurse

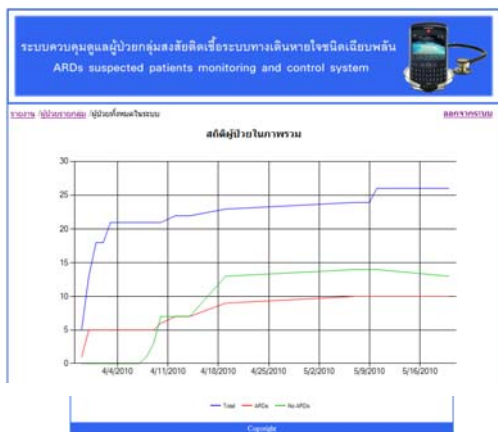**Figure 8** Total patients report page

Esichaikul, Rermlawan, and Becther

Figure 9 ARDs trend report page

Figure 10a)

Figure 10b)

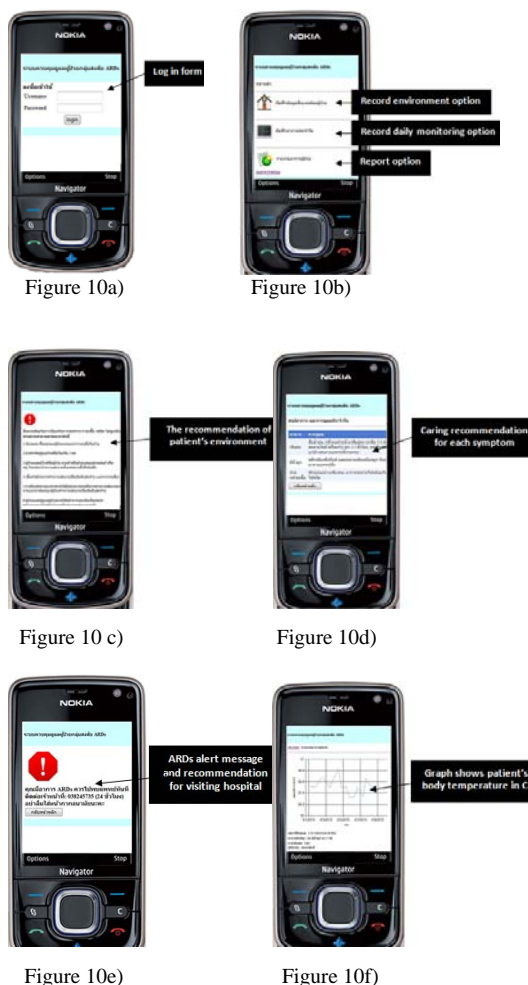Figure 10 c)

Figure 10d)

Figure 10e)

Figure 10f)

Figure 10(a-f) The examples of mobile client user interfaces

SYSTEM IMPLEMENTATION AND EVALUATION

The system was implemented on laptop with Windows Vista operating system. ASP.NET programming language was used to create all functions in the system. The MD chart.exe and MS chart_VisualStudioAddOn.exe were installed as the adding components of Visual Web

Developer 2008 Express Edition for providing all chart images in the system. The suspected ARD patient monitoring and controlling system was run on an Ms SQL 2008 server. However, two inconveniences were experienced in the deployment process. Firstly, chart images could not be displayed, and secondly, Ms Access 2007 database could not be accessed. These two problems came about from a mismatch between the server and the development environment. Thus, to display chart images, an image chart control component was added into the web configuration file. For database connection, the MS Access 2007 database was changed to MS Access 2003 version. After the web configuration was edited and changed to MS Access file format, the error messages disappeared.

All functions and user interfaces in the system were tested separately based on system use-cases. Four tests were conducted: namely, integration testing, system testing, multi-platform testing, and acceptance testing. The system passed in all test processes of each testing. To be platform-independent, the system was tested on four mobile operating systems: 1) Symbian (Nokia 6210 Navigator); 2) MS Windows Mobile (HTC P3400i); 3) Rim BlackBerry (BlackBerry Bold 9000, curve 8900); and 4) Apple iPhone (iPhone 3G). All of the devices could fully operate all functions in the system. Text and image navigation were linked to the valid target with correct attached variables. All the mobile devices showed the structure of the display as designed. However, the iPhone 3G showed small displays when it initially accessed every page. To solve this problem, the iPhone 3G's zoom function was adjusted in order to show display screens clearly.

For system evaluation, the system was evaluated in four aspects (information quality, system quality, decision support tool, and the overall of the system) by hospital staff and patients from Royal Thai Marine Corp Health Care Unit. The system evaluation was based on a 3-point rating scale (3=strongly agree, 2=agree, 1=disagree). 20.83% of hospital staff rated the mobile application as "agree" in term of "easy to learn how to use the system" (average score 2.79). 13.64% of patients rated as "agree" in term of "easy to learn how to use the system" (average score 2.86). 36.36% of patients vote as "agree" in term of "ease of use" (average score 2.64). These results maybe come from the difference of user experience especially mobile users; all participants never operated on mobile web application before they used the system to monitor themselves. Moreover, some hospital staffs are familiar with paper-based working style.

Esichaikul, Rermlawan, and Becther

CONCLUSION AND RECOMMENDATION

In the past decade, there have been many ARD epidemics, and they have spread across the world because the early symptoms are similar to a simple respiratory tract infection. However, since some suspected ARD patients have good vital signs, and the number of hospital beds for admitting infectious patients is limited, physicians allow home care for them. As a result, this group of patients often spreads their contagious pathogens into the community because they are not monitored and controlled properly. Many mobile applications are applied to health care services, but most of them aim to improve the data collection capability. Some of them aim to keep track of home care patients, but in such cases, the developed mobile application is a platform dependent application. This study successfully developed a platform independent mobile application to keep track of patients, and then used the data to support decision making in order to care for patients with suspected ARDs.

The system was developed using object oriented analysis and design. Two requirements were essential; since the system was developed as a medical application, both domain knowledge in ARDs and user requirements were needed to design the system. The results of interviews with experts and the clinical practice guidelines for AH1N1 were used to create a pattern to monitor and control suspected ARD patients. The use-case diagram, class diagram, sequence diagram, activity diagram, and deployment diagram were designed based on users' requirements. Two main user groups used this system: the hospital staff and patients. The hospital staff accessed the system through a PC or laptop, and the patient group accessed the system through a mobile phone. A patient identification number or HN was used to identify patients in the hospital information system (HIS), and it was used as a key to access the system.

To evaluate the system, the hospital staff used a laptop to operate the system, while patients used a mobile phone. The system was evaluated for information quality, system quality, decision support tools, and the overall satisfaction with the system. Some hospital staff participants in the evaluation process commented on the need for more patient information on ARD symptoms to be provided by the system. For some hospital staff, it was difficult to operate the system due to little computer experience as they usually work in a paper-based format. However, all hospital staff were satisfied with the overall system. Patients commented on the need for more information related to the care required of ARD symptoms from the system, such as knowledge related to ARD prevention. Some patients had never operated an application on a mobile phone, thus they thought it was not easy to use or learn the system. However, most patients were satisfied with information quality, system quality, decision support tools, and the overall system.

In the future, the system should be developed to support new coming mobile phone, such as 3G and 4G mobile phones. The system should be further tested and evaluated during the epidemic season with a higher number of participants and various user groups, especially mobile clients. This system can be applied to other domains of home care for disease(s) with time-dependent disease pattern (DHF, abnormal fetal movement in pregnancy, and head injuries); they have a suspected status which their symptoms have to observe. The system can be further developed as a network approach for monitoring and controlling epidemics in communities.

For future work, to effectively control epidemics, a Geographic Information System can be integrated into mobile web applications. The patients' landmark location (latitude and longitude) will be new data fields included the database and used to display the epidemic areas (epidemic zone, warning zone, and safe zone). Mobile clients can display the map in terms of map image that are already computed in the server. This study applied a rule-based model as the decision support pattern for suspected ARD patients. However, a future decision support model can integrate a case-based model with a rule-based model to predict the symptoms and provide the proper solutions for patients in each case. In addition, mobile web applications can be developed to connect with portable medical machines, such as blood glucose meters and blood pressure monitors. From the connection, blood pressure and blood glucose data can directly be tracked and sent to the server for real time monitoring of patients with chronic disease.

REFERENCES

[1] ASP.NET Developer Center (2009). *Mobile Web Development Overview*. Retrieved October 2009, http://msdn.microsoft.com/en-us/library/ms178619(VS.80).aspx

[2] Caresearch (2009). *Home visits.* Retrieved September 2009, from http://www.caresearch.com.au/caresearch/ProfessionalGroups/GPHome/MakingitWorkinYourPractice/HomeVisits/tabid/1176/Default.aspx

[3]Cell-life. *EMIT*. Retrieved October 2009, from Cell-life Website: http://www.cell-life.org/emit

[4] Cell-life. *iDART*. Retrieved October 2009, from Cell-life Website: http://www.cell-life.org/idart

[5] Chinese Aged Diabetic Assistant(CADA). Retrieved October 2009, http://www.cadaproject.com/

[6] Colecta-PALM. Retrieved November 2009, http://colectapalm.org/

[7] Deressa, W., D. Olana , and S. Chibsa. (2005). Community participation in malaria epidemic control in highland areas of southern Oromia, Ethiopia. *Ethiopian Journal of Health Development.*, 19 (1), 3-10.

[8] Department of Communicable disease Surveillance and response World Health Organization (2003). *Consensus document on the epidemiology of severe acute respiratory syndrome (SARS)*. Retrieved September 2009, http://www.who.int/csr/sars/en/WHOconsensus.pdf

[9] Department of health (2008). *Home Visits by Medical Personnel*. Retrieved September 2009, from New York States website: http://www.health.state.ny.us/facilities/long_term_care/waiver/nhtd_manual/section_06/home_visits_by_medical_personnel.htm

[10] Division of Prevention & Control of Communicable Diseases (DDC) WHO/AFRO. *Implementation of Epidemic Control Actions by the DRRT and the Members of the Community*. Retrieved September 2009, from http://www.afro.who.int/emc/implementation.html

[11] Dorak, M. T. (2008). *Epidemiology of Infectious Diseases*. Retrieved September 2009, from http://www.dorak.info/epi/epiin.ppt

[12] Freebase (2009). *8 Route of infection transmission*. Retrieved September 2009, http://www.freebase.com/view/base/infection/views/transmission

[13] Gubler D. J. (2006). Dengue/dengue haemorrhagic fever: history and current status. Retrieved September 2009, from National Center for Biotechnology Information , U.S. National Library of Medicine website: http://www.ncbi.nlm.nih.gov/ pubmed/17319151

[14] Mashavu: Networked Health Solutions for the Developing World, Retrieved November 2009, http://www.ideablob.com/ideas/1528-Mashavu-Networked-Health-Solu

[15] Michigan Department of Education Early Childhood Programs (1999). *A Guide to Home Visits.* Retrieved October 2009, from http://www.docstoc.com/docs/7257956/2-A-Gui de-to-Home-Visits

[16] Microsoft Corporation (2008). *Microsoft Visual Web Developer 2008 Express Edition*. Retrieved October 2009, from http://www.microsoft.com/express/vwd/

[17] Microsoft Corporation (2009). *Mobile Web Application Architecture*. Retrieved October 2009, http://www.asp.net/mobile/architecture/

[18] Mobile Care, Support and Treatment Manager (MCST), Retrieved November 2009, http//www.freedomhivaids.in/mCST.htm

[19] Occupational Health and Safety Section (2007). *GUIDELINES for Home Visits*. Retrieved October 2009, from La Trobe University website: http://www.latrobe.edu.au/pc/ohs/ohs-manual/home-visit.pdf

[20] Olla, P. and J. Tan (2006). The M-Health Reference Model: An Organizing Framework for Conceptualizing Mobile Health Systems. *International Journal of Healthcare Information Systems and Informatics*, 1 (2), 1-19.

[21] Parashar, U.D. and L. J. Anderson (2004). Severe acute respiratory syndrome: review and lessons of the 2003 outbreak. *International Journal of Epidemiology*, 33 (4), 628-634.

[22] SIMpill Solution for TB. Retrieved November 2009, http://www.SIMpill.co.uk

[23]Virtual Health Pet, Retrieved November 2009, http://www.tridedalo.com.br/fabiane/index.htm

[24] Vital Wave Consulting (2009). *mHealth for Development: The Opportunity of Mobile Technology for Healthcare in the Developing World*. Washington, D.C. and Berkshire, UK: UN Foundation-Vodafone Foundation Partnership.

[25] Windows Mobile Developer Center (2009). *Windows Mobile*. Retrieved October 2009, from http://msdn.microsoft.com/en-us/library/bb847935.aspx

[26] Woolhouse, M. and S. Gowtage-Sequeria (2005). Host Range and Emerging and Reemerging Pathogens. *Emerging Infectious Diseases*, 11 (12), 1842-1847.

[27] World Health Organization (2007). *The world health report 2007 : a safer future : global public health security in the 21st century*. Retrieved October 2009, from http://www.who.int/whr/2007/en/index.html

[28] World Health Organization Western Pacific Region (2008). *Asia-Pacific Dengue Program Managers Meeting*. Retrieved September 2009, http://www.wpro.who.int/internet/files/mvp/Dengue_Report.pdf