Enhanced Asthma Management with Mobile Communication

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Abstract—**In this paper, we propose a prototype system to enhance the management of asthma condition in patients who are also users of mobile devices. This system provides convenience to patients as well as facilitates the interaction with their doctors. The enhanced interaction enables a timely and cost effective management of asthma conditions by both patients and medical practitioners.**

Index Terms—**Asthma management, Healthcare IT**

I. INTRODUCTION

THE World Health Organization/Global Initiative on Asthma (WHO/GINA) reported that Singapore is an intermediate-risk country for asthma prevalence. It affects around 5% of the population. Singapore also has one of the highest rates of asthma deaths in the world. Asthma related deaths are mostly preventable with appropriate treatment. A proactive asthma management mechanism would generally require daily preventive medication and regular physician reviews [1].

Traditionally, asthma patients would need to maintain daily records of their asthma conditions on paper, and provide the information to doctors on their next visit [2]. Such a method for records keeping is inconvenient to the patient, especially one who travels frequently, e.g. due to work requirement. The information collected this way may not be timely or reliable as patients might have forgotten the details on some days. Even if the records are kept accurately, the doctor would only get to see them on the next visit, which can incur one or several months of delay. If a patient's condition deteriorates some time before the next visit, the doctor will not be aware of it and thus missing the earliest opportunity to provide appropriate medical treatment. Moreover, any changes in the patient's condition may render the previously prescribed medication outdated and/or ineffective, thus increasing the cost of asthma management in the long term. Also, such ineffective medication may cause unnecessary suffering to the patient if both doctor and patient are not alerted of the situation in a timely manner.

This paper presents a prototype system to address the above problems. The system provides a timely and cost effective solution to bridge the information gap between asthma patients and doctors. The social and healthcare costs of delay in information flow are thus minimized. The system also provides a convenient mobile input interface for asthma patients to maintain daily records.

In this prototype, an Android mobile device and Apache Tomcat server are used to implement the system, as illustrated in Figure 1. As both platforms are open source, the cost of development would be low.
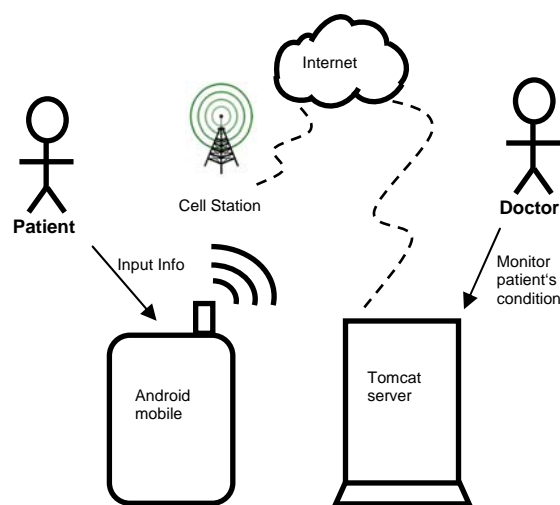

Fig. 1. Illustration of the prototype system.

The increasing popularity of Android makes it a great platform to leverage on. Many mobile device manufacturers have adopted Android as their choice of operating system. Such mobile devices are widely available at different price range [3]. The software can be distributed easily through Google market, which is well established for users to obtain applications from developers [4].

The prototype's mobile application has been designed with simplicity so that it can run on most Android platforms. It replaces the cumbersome paper recording method, yet is able to capture essential daily information regarding the patient's asthma condition and organize the data for presentation to doctors.

Java Server Page is used on Apache Tomcat server to provide doctors with access to the patients' daily records. The information captured and submitted by a patient's mobile device can be readily reviewed by the doctor. In this way, the asthma condition of the patient is monitored by the doctor in a timely manner. Any unanticipated deterioration in the asthma condition can be detected and treated without delay. We believe this will significantly enhance the management of asthma by both patients and medical professionals.

II. PREVIOUS WORK

The traditional method for monitoring asthma condition uses a paper form similar to the Asthma Daily Record Card [2] reproduced in Figure 2. The patient notes down daily whether or not he has asthma symptoms such as breathlessness, coughing or wheezing. He also needs to write down the daily peak flow test results and show the records to doctors on the next visit.

Fig. 2. Asthma daily record card.

An alternate way of recording the data, such as using personal computer software like Asthma Assistant [5], as shown in Figure 3, has been available for several years. The software allows a patient to enter the daily records on a local computer's database. The details recorded are similar to those on a traditional paper form. Another personal computer software that assists asthma management is My Peak Flow [6], as shown in Figure 4. In both applications, the patient has to print a copy of the report from the software, and show it to the doctor on his next visit.

While the software provides a more convenient and robust method for the patient to maintain the daily records, it does not improve the level of interactivity between patients and doctors. The doctor will not be aware of changes in the patient's condition until his next visit.
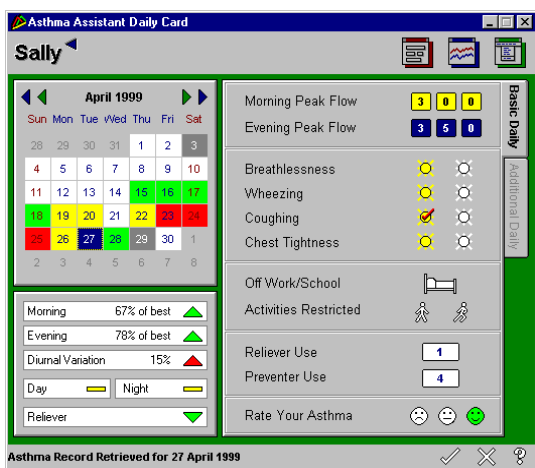

Fig. 3. Asthma Assistant Daily Card.

There are also mobile software products on asthma management. Figure 5 shows the Android application My Asthma Log, which a patient can use to keep a log of his daily asthma records [7]. However, to the authors' best knowledge, there is no mobile software made conveniently available to patients which also provides the doctors with up to date information to facilitate proactive asthma management.

Fig. 4. My Peak Flow software.

Fig. 5. My Asthma Log mobile phone software.

III. PROTOTYPE SOFTWARE APPLICATION

There are two parts of the application software, one for the patient and the other for the doctor. They have been developed on the mobile and server platforms respectively.

A. Mobile Application for Patients

The mobile application would be installed on the patient's personal mobile phone. A patient is expected to record his asthma condition on a daily basis. If an asthma attack occurs, the patient is expected to update the incident on the mobile phone. In additional, the application provides a useful feature

for the patient to notify his caregiver using SMS (Short Message Service). If the mobile phone is equipped with a GPS (Global Positioning System) sensor, the patient's current location is included in the same SMS message. This feature ensures that the patient can be taken care of as soon as possible in the event of a sudden asthma attack, which can be life-threatening.

Upon a fresh installation of the application on a mobile phone, the user needs to follow a few simple steps to configure the system. The configuration menu is shown in Figure 6. Parameters such as user id, password, and server URL are mandatory for proper connection to the server application intended for the doctor. The SMS address can be configured to alert the caregiver when the patient submits an asthma attack incident report on the mobile phone.
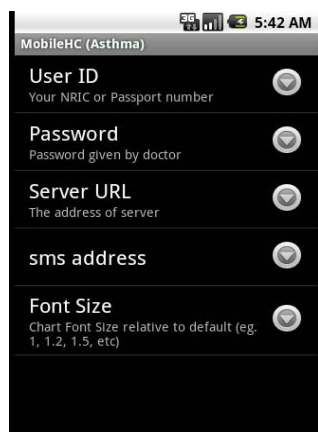

Fig. 6. Configuration for login and notification parameters.
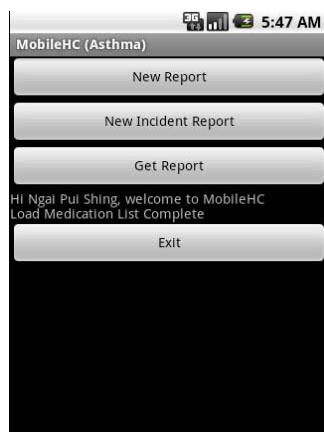
Fig. 7. Mobile Application Interface.

The user will be logged into the application once the configuration is completed. Upon a successful login, the patient's personal asthma medication list is automatically retrieved from the server. The list will typically include 2 types of medication: Fast Acting medication and Long Term Control medication. The purpose of retrieving this list from the server is to ensure that the patient is fully aware of the medication that has been prescribed to him by the doctor.

On the main menu of the mobile application, there are three functions: namely new report, new incident report, and get report, as shown in Figure 7. New report is for maintaining daily records of the patient's condition; new incident report is for reporting an asthma attack; get report is for the patient to review the records that he has updated on the mobile phone.

1) Daily Report

Similar to the traditional method, asthma patients are strongly encouraged to monitor their conditions on a daily basis. A patient should therefore submit a daily report regarding the presence or absence of various asthma symptoms, including breathlessness, wheezing, chest tightness, and coughing. Other important details such as peak flow (as shown in Figure 8) and the dosage of prescribed medication taken (as shown in Figure 9) are also captured. All these records, together with an optional text message to the doctor, will be submitted to the server. Most importantly,

the information is accessible to the doctor as soon as he logs in to the server.

By collecting the patient's condition on a frequent and regular basis, a doctor would be equipped with timely information to assist in the diagnosis process. It helps both the patient and doctor to work out a better asthma management process. When a patient's condition changes unexpectedly or if there is any abnormality, the captured information would be helpful for doctors to detect it at the early stage of change.
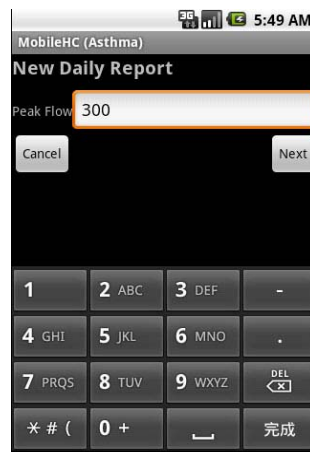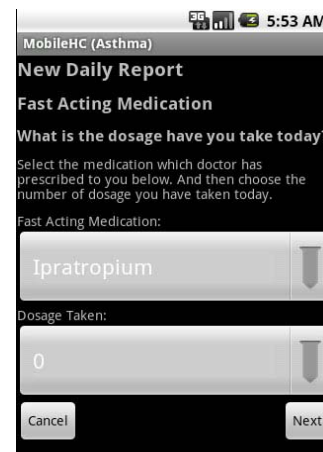

Fig. 8. Capturing peak flow value.

Fig. 9. Capturing medication dosage.

2) Asthma Attack Incident Report

In the event of an asthma attack, the patient is encouraged to record relevant and vital information by using the incident report on the mobile phone. If the patient is not able to do so immediately, he should submit the incident report when the attack has subsided after taking a fast acting medication. This report logs the peak flow rate, date and time of the incident, the possible triggers of the asthma attack (as shown in Figure 10) suspected by the patient, the dosage of fast acting medicine used to control the attack and an optional message to the doctor (as shown in Figure 11).

It may seem demanding on the patient to record the above details when he is suffering from an asthma attack. However, it is important for achieving an effective long term management of the patient's condition and reducing the risks of severe attacks and costly hospitalization.
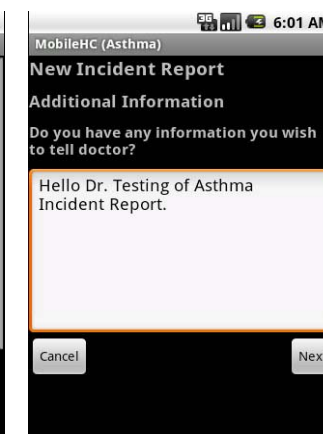

Fig. 10. Possible triggers of the incident.

Fig. 11. Additional information for the doctor.

When submitting the asthma incident report, a patient has the option to notify his caregiver of his current location using an SMS message, as shown in Figure 12. The location service is provided by either cell based location or GPS based location, depending on the availability of the location services.
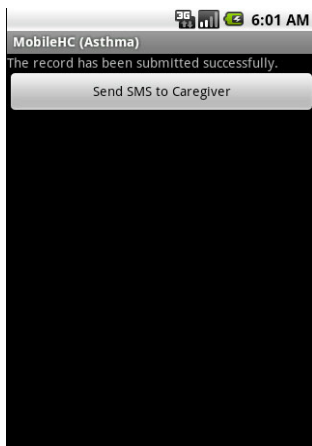

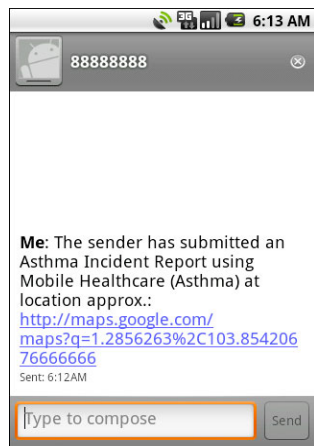Fig. 12. Optional notification to caregiver.

Fig. 13. A message sent with the location parameters.

The caregiver notification is made optional to provide flexibility for the patient to protect his privacy. The location information is neither collected by the server nor stored in the application. When the option is selected, if the patient stays indoor or the GPS module on the device is unable to locate sufficient satellites, cell based location service would be used to provide the approximate coordinates to notify the caregiver on the current location. Figure 13 shows a sample message sent with the Android messaging application.

When the caregiver receives an SMS notification message with the patient's location information, he can view it easily on Google Map as shown in Figure 14. This helps the caregiver to decide on the best course of action in rendering assistance to the patient.
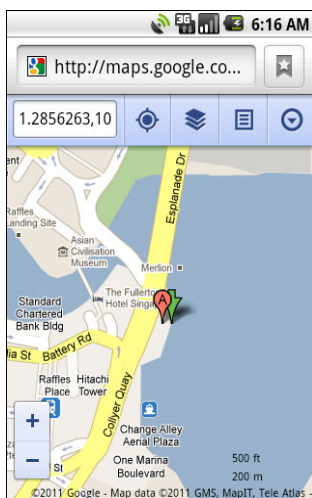

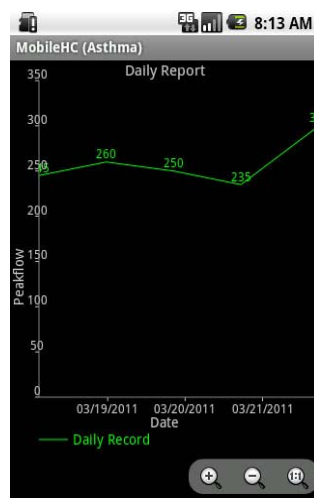Fig. 14. Caregiver viewing location of patient.

Fig. 15. Review of peakflow data.

3) Reports Submission Review

Patients can review their reports submission history from the mobile platform in a chart form, as shown in Figure 15. However, details of the submission are only available to doctors accessing the server due to the limited screen size on the mobile device.

B. Server Application for Doctors

For effective and timely asthma management, doctors are strongly encouraged to review the daily reports submitted by patients to monitor their conditions regularly. Should a patient's records show any abnormality, proactive measures can be taken by the doctor to alleviate the problems, instead of passively waiting for the next scheduled visit of the patient.

To view the submitted reports, a doctor will log in to the server application over a web interface. A list of submissions from different patients will be shown on the main page as shown in Figure 16.
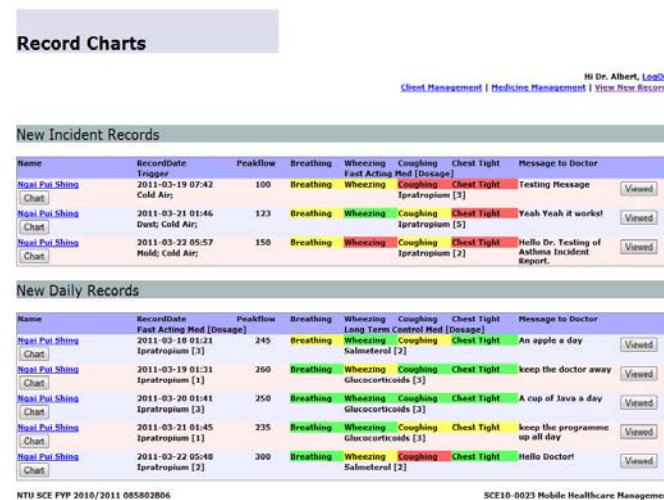

Fig. 16. A list of submissions for doctors to review.

The incident reports and daily reports are separated into two different parts on the display to improve readability. All the details submitted by patients are displayed. Breathing difficulties, wheezing, chest tightness, coughing problems are shown in different colors – green, yellow and red to reflect the severity of the patient's condition. Peak flow and medication dosage are also shown on this page. Additional information such as the patient's particulars and historical data can be easily viewed by clicking the corresponding links. In other words, all vital information is at the doctor's finger tips.

The doctor can select a particular patient and view the detail report. As shown in Figure 17, the charts of daily reports and incident reports are displayed to assist the doctor in diagnosis. With this information, the doctor can make appropriate and timely clinical decisions, such as calling up the patient for an immediate review, or changing the prescription or dosage if necessary.
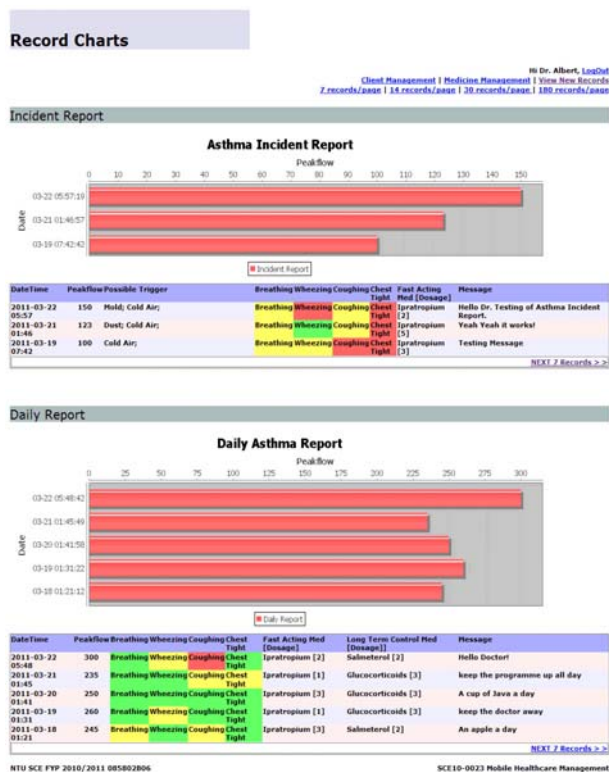
Fig. 17. Detailed records of a selected patient.

The server application includes a provision for system administration functions such as updating the list of patients, list of doctors and the list of medications. Different doctors using the system are able to maintain specific medication lists for individual patients.

IV. CONCLUSION AND FUTURE WORK

We have demonstrated how a computerized healthcare system based on mobile communication can be designed and implemented to improve long term asthma management for patients. Our prototype system is able to bridge the information gap between patients and doctors. This feature is important for doctors to administer timely treatment to asthma patients. By doing away with the traditional paper recording method, patients can now monitor and record asthma symptoms in a more efficient and accurate manner. For the individual patient, we believe this can greatly reduce the risk of severe asthma attacks and costly hospitalization.

The system is also beneficial to doctors, who can easily review a patient's records prior to the medical appointment. At a higher level, when the records are used collectively and anonymously, they can provide valuable information and insights on asthma related issues in the local region, such as the effectiveness of different medications and dosages for different types of patients and asthma triggers.

The current prototype has its limitations. The user interface on the mobile application requires many data inputs from the patient. This results directly from the decision to adhere closely to the traditional paper form so as not to risk losing any vital information in the process of computerization. With further advice from doctors who are familiar with asthma patient care, we hope to reduce the amount of data that need to be entered by the patient. For the doctors, we hope to add some intelligence in the server

application to provide better clinical diagnosis support. For example, by including thresholds established by medical professionals for certain symptoms or profiles for peak flow trends, the system can help doctors to quickly identify patients who need more immediate attention.

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