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Development of a Mini-OCS System for Voluntary Medical Services in the Challenged Regions☆

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ABSTRACT

In this paper, we present our recent effort on the development of a portable OCS system (SCH-mOCS), which provides minimal but essential functionalities of conventional OCS systems. SCH-mOCS is targeted for the environment where Internet connection is not available and fast processing of essential patient information is needed. The main usage could be found at the outdoor environment, such as voluntary medical services at challenged regions. The target of the first usage of the system is in the rural area of Cambodia where medical service and ICT infrastructure is poor. We have been conducting voluntary medical services for 15 years in Cambodia, where the services usually run for 3 days and include outpatient diagnosis/consultation, medication, and simple surgeries. This medical service started in 2002, where about 20 SoonChunHyang University Bucheon Hospital staffs (doctors, nurses, and pharmacists) participated. We realized that a system like SCH-mOCS is needed: we have to consult many patients in a short period, so that a prompt response and prescription to the patients are very important. However, the conventional OCS system is not suitable, because the service is usually conducted outdoor environment where Internet connected computers cannot be installed. Moreover, since the service needs only a subset of the conventional hospital information system and fast system response, application of a full OCS is not practical. The adequate system is a bare minimal OCS system, with very simple and quickly manageable patient admission, consultation, and prescription functionalities. In this paper, we describe hardware as well as the software aspect of a mini-OCS we have developed for the purpose. We named the system SCH-mOCS (SoonChunHyang mini-OCS). We also describe the usage scenario of SCH-mOCS in order to demonstrate that the system is general enough to apply for other similarly challenged regions.

☞ keyword : OCS (Order Communication System), Voluntary Medical Service, Patient Prescription, Wireless Communication, Medical ICT Infrastructure

1. Introduction

We have been conducting voluntary medical services in the rural area of Cambodia for more than 15 years. This service started in 2002, where about 20 SoonChunHyang University Bucheon Hospital staffs (doctors, nurses, and pharmacists) participated. The service usually runs for 3 days and includes outpatient diagnosis/consultation, medication, and simple surgeries. The sustained services have been possible because of the training program at SoonChunHyang University Bucheon Hospital. The hospital invites 3~4 Cambodian doctors for one year training program, fully supporting all the expenditure. This program has started in 2004 and now we have 56 trained doctors. After going back to their homeland, these trainees provide good medical practices and act as partners for us to deploy useful medical service programs for the country, including voluntary medical services each year [1]. The services mainly focus on the outpatient consultation, but it also may include simple surgeries such as cleft lip, herniotomy, and cataract surgery. Since there are many patients attending the services (at least a few hundreds per day), we realized that we need a digitalized patient admission and prescription system to be able to handle more patients and to give them better services.

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Also, recently, we realized that the data acquired form the services is important to plan voluntary medical services for other challenged areas. However, the conventional OCS systems [2,3] is not suitable, because the service is usually conducted outdoor environment where Internet connected computers cannot be installed. Moreover, since the service needs only a subset of the conventional hospital information system and fast system response, application of a full OCS is not practical [4]. The adequate system is a bare minimal OCS system, with very simple and quickly manageable patient admission, consultation, and prescription functionalities.

In this paper, we describe hardware as well as the software aspect of a mini-OCS we have developed for the purpose. We named the system SCH-mOCS (SoonChunHyang mini-OCS).

The rest of the paper is organized as follows; In Section 1, we provide the rationale behind the development of SCH-mOCS. In Section 2, we briefly explain medical environment (including demographical and socioeconomical status) of Cambodia where the designed system is currently targeted. Section 3 describes overall system structure and hardware aspect of the development. Section 4 concentrates on the software development of SCH-mOCS. Section 5 gives a prototype development result of the system and discuss its field application. Section 6 discusses future direction toward the improvement of SCH-mOCS, and concludes.

2. Target Country Analysis[5]

Year 2012 statistics show that Cambodia has about 14 million population and 80% of them live in rural area. There are 24 provinces, and 55% of urban population live in Phnom Penh, the capital of the country. Life expectancy is 71.4, and the aged population (over 65) is 5.3%, which is rapidly increasing. The young (under 15) is 31.2%. Infant mortality is 33.9/1000 and under-5 mortality is 39.7/1000 which is higher than other countries in South-Asia.

Most people work for agriculture, fishery, timber, and livestock. Recently garment and shoes industry is prospering in urban area. GDP per capita is US $955. National poverty line ($0.95) is falling from 50% (2004) to 20% (2011), indicating that the living condition is improving, but there is large inequalities in all aspect of living condition between the rural and urban area.

Public health system is structured in a well-defined hierarchical fashion. The Ministry of Health (MOH) is solely responsible for the organization and delivery of governmental health services, through 24 MOH Provincial Health Departments (PHD), and 81 health Operational Districts (OD). Each PHD and OD has a Referral Hospital which covers population of 100,000~200,000. There are more than 1000 Health Centers, each of which covers 10,000~20,000 population. There also are near 100 Health Posts, and they provide less services than the Health Center. They are placed for the area where a nearest Health Center is more than 15km away. They cover 2,000~3,000 population.

However, the public health system is not functioning well yet, because of the lack of medical staffs at the Health Center. Most of the Health Centers (about 75%) have no medical doctor and rely on nurses and midwives. Therefore, we perform annual voluntary medical service mostly in the rural area where the health care service provision is deficient.

Through many years of services, we found that the service is very time consuming and inefficient, so that ICT based management would help provide more prompt and effective services to the patient. This have motivated our study.

3. Design and Implementation

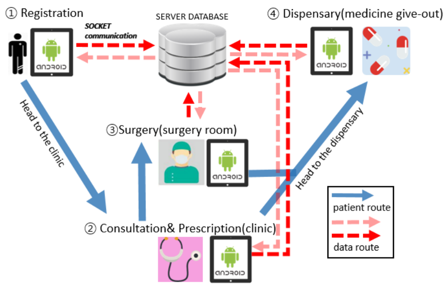
3.1 Service Overview

We formed a local area network based on TCP/IP protocol with various portable devices, such as routers, tablets, and a server. All communication among devices are wireless, and to make the communication range wider, we used amplifying antennas. For the data entry and display, we used portable devices with Bluetooth capability.

We have developed software modules from the scratch. With continuous interview with many doctors and service participants, we have designed a database schema suitable for the service. Based on the schema, we developed server-side logic as Java modules. To make mobile clients access database server efficiently, we used the TCP/IP socket interface. We developed mobile clients' UI in Android to give neat and easy user experience [6].

3.2 Service Flow

Overall flow of the voluntary medical service is given in Figure 1. Bare minimal OCS functionalities are given. They are ① patient registration, ② consultation and prescription, ③ surgery admission, and ④ medicine dispensary.



(Figure 1) Flow of the service

In conventional voluntary medical services, patients had to hold their paper chart throughout the service. This was a hassle to the patient as well as to the service personals. Because of the language barrier, patients could not be identified easily and this could lead to a wrong medication.

In these needs, we prepared the barcode labeling for patients (Figure 2). Now patients are identified by the barcode wrist-band and can be easily identified through the barcode scanner and the handling software module.

(Figure 2) Wrist-band type barcode label

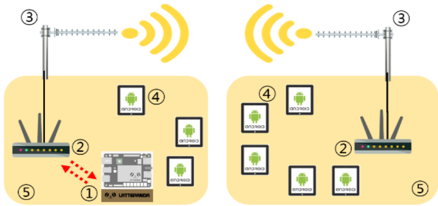
One other problem with the paper-based patient administration is in the medicine stock counting. We could not tell what kind and how much medicine we have in stock that we can prescribe. Also, with the paper-chart based procedure, we cannot consult the patient efficiently, so that the waiting time of the patient becomes long. This implies that the service staffs' time is not efficiently managed as well.

3.3 System Structure

3.3.1 Hardware Structure

We developed a system, where users can use Android based mobile devices for the services. Doctors, nurses, pharmacist, receptionists, and surgery room staffs use mobile devices for the service. Each staff logs on to an appropriate client program and conduct the role they need to perform. For easy manipulation, they are given with a Bluetooth keyboard, a mouse, and a barcode reader. The overall H/W structure of the system is shown in Figure 3.

It is consists of ① a server, ② routers, ③antennas, ④ tablets, in a wireless communication zone(⑤).



(Figure 3) Hardware structure of SCH-mOCS

The server (①) is available to clients through routers (②). It needs not be connected to the Internet, because all communication is confined to the local service area (⑤). To make the communication range wider, we provide several antennas in the area. The server is a small-size embedded module (Lattepanda [7]), so that we can install the system very quickly and easily.

3.3.2 Software Development

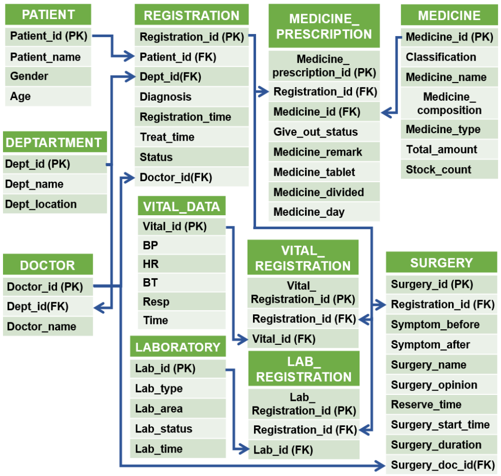
■ Database Design

In order to implement the SCH-mOCS, we designed a database schema as in Figure 4. Actual database is built on a MySQL server [8]. All application is written in Java on Android and the database is accessed via MySQL JDBC driver.

The tables in the schema consist of minimal but essential columns. Here we briefly describe their roles and formats:

PATIENT table stores basic patient information. The primary key *patient_id* acts as a reference of a patient to other tables that handle consultation, examination, prescription, and surgery.

DEPARTMENT table is for the department name, and it can give locational information such as room number of the department.



(Figure 4) SCH-mOCS Database Schema

DOCTOR table provides doctor's name and departmental information through 1:N relationship with *DEPARTMENT* table.

REGISTRATION table holds the entries that are created upon registration of out-patients (per visit). The primary key registration_id is used for consultation, laboratory examination, prescription, and surgery registration.

MEDICINE_PRESCRIPTION table is for the N:N prescription relationship between *REGISTRATION* and *MEDICINE*. Using the *patient_id* from *PATIENT* table, we extract *reception_id* from the REGISTRATION table, and associate it with *medicine_id* from the *MEDICINE* table, to give details of the prescription. So, we can have information on to whom the medicine has to be given. The *give_out_status* column indicates whether the medicine is given-out to the patient or not. Through the *medicine_remark* column, doctors may pass messages to the pharmacist, such as the count of the pills, number of medication per day, and its duration. Detailed information on this can be found in Section 3 (Figure 9).

MEDICINE table holds the information about the medicine. The classification column indicates whether it is a predefined prescription or individual prescription. Predefined prescription means that the medicine is prepared in a bundle for easy dispensary. Individual prescription indicates the usual individualized medicine prescription. In the case of predefined prescription, the composition column specifies name of the medicine and its count. For individual prescription, it tells the ingredient and the count of the medicine. The *medicine_type* tells the type of medication which are one of the value from the following: PACK, TUBE, BOTTLE, CAPSULE, and TABLET.

SURGERY table holds the information related to surgeries, such as the pre and post symptoms/conditions of the patient. It also contains name of the surgery, and doctor's remarks as well as other surgery related information, such as reservation information, beginning time and completion time of the surgery.

VITAL_REGISTRATION table is there to give N:N relationship between *VITAL_DATA* table and *REGISTRATION* table. Because of this table, various and multiple vital sign checkups for the patient can be registered.

VITAL_DATA table holds BP (Blood Pleasure), HR (Heartbeat Rate), BT (Body Temperature), and RESP (Respiration Rate) data.

LAB_REGISTRATION table represents N:N relationship between *LABORATORY* table and *REGISTRATION* table. Through this table, various multiple laboratory test data can be registered.

LABORATORY table contains type, body region, status, and time of the lab test.

■ Server/Client logic design

Server/client information request is implemented over TCP/IP. Java Socket interface is used for communication application implementation. A wireless connection to the local network was possible by the WIFI enabled routers. Figure 5 depicts the server/client information handling mechanism. The communication logic is as follows:

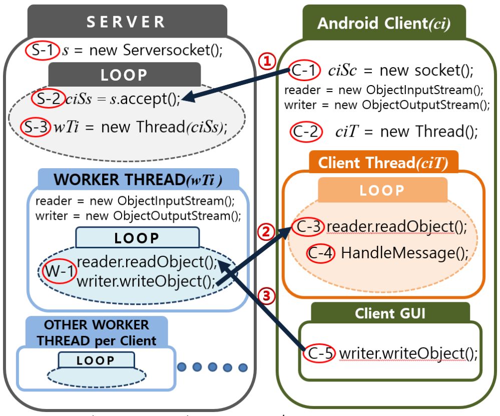
<Server-Side>

- Server creates ServerSocket *s* that can create multiple socket channels (S-1)
- Then, the server waits for a client connection on *s* in an infinite loop (S-2)
- Once the connection request is accepted, the server gets a socket *ciSs* for the client *ci*, and creates a worker thread *wTi* for passing along the *ciSs* for communication (S-3)
- Thread *wTi* creates a readerstream and a writerstream from the socket *ciSs* (S-4)

- Thread *wTi* waits for the write message from client *ci* on the readerstream (S-5)
- If there is something that needs to be sent to the client *ci*, *wTi* uses its writerstream (S-6) to do that

<Client-Side>

- Client creates socket *ciSc* for communication (C-1)
- Once the socket *ciSc* is connected, the client *ci* creates a readerstream and a writerstream over *ciSc*
- The client *ci* creates thread *ciT* to receive messages from the server (C-2)
- The thread *ciT* waits for the server message in an infinite loop (C-3)
- Thread *ciT* handles each incoming message (C-4)
- The message to send to the server from the client *ci* is made through its writerstream over *ciSc* (C-5)



(Figure 5) Server/Client logic

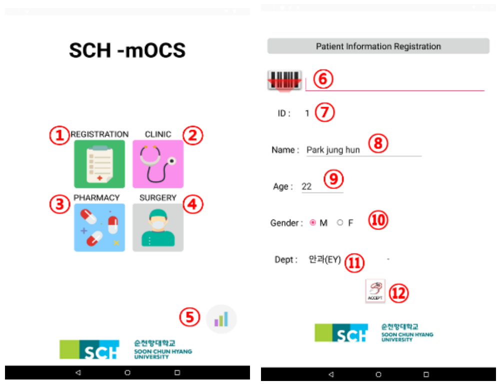
In Figure 5, ① represents the server connection request from the client to the server. After server creates a worker thread *wTi* for the client *ci*, their reader and writer streams are used for the message exchange (②, ③).

4. SCH-mOCS Implementation

We have developed SCH-mOCS application over the Android mobile platform. Android widgets are used intensively to minimize user typing. For example, we used Android widgets such as Listview and ComboBox as much as possible to minimize time for input, so that the turnaround time of the consultation is short. For an easy access to existing patient information, we provided a search capability to the application through barcode reading or text input.

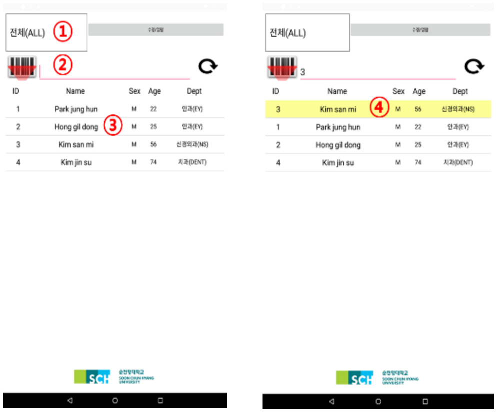
Figure 6 is the application's main UI. Medical service staffs can choose among 5 major functionalities of the app: they are ① *Registration* (patient registration), ② *Clinic* (consultation and prescription), ③ *Pharmacy* (medicine dispensary), ④ *Surgery* (simple operations), and ⑤ various statistical and status information.

When the *Registration* (①) is selected, we get the UI of Figure 6 (b). If the patient is a first-time visitor, we provide a barcode wrist-band. The barcode reader guided by ⑥ asks for the barcode scanning, and the scanned id is displayed in ⑦. Patient information includes name (⑧), age (⑨), gender (⑩), and department (⑪). The S/W system registers the information to the DB server when the button (⑫) is selected. For the patient who has a wrist-band already, multiple registration is possible by reading the barcode again. In this case, the receptionist can modify the department and other consultation related information, if necessary. Once the registration of a patient is complete, all entry boxes are reset to handle next patient.

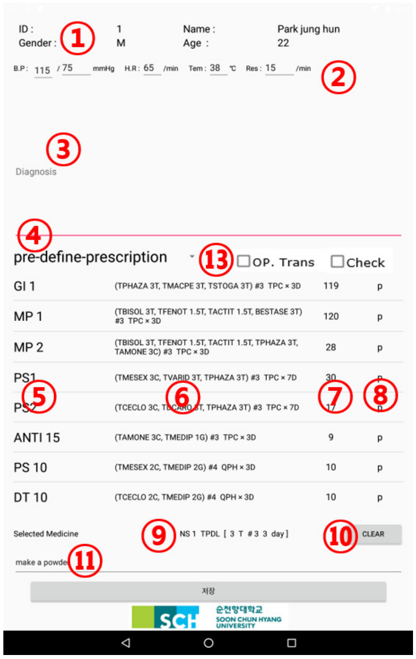


(Figure 6) (a) Main UI (b)Patient registration

Figure 7 is the *Clinic* UI which we get into by choosing ② in the main UI (Figure 6(a)). Doctors may choose Department (①) and select a next patient for consultation by using the barcode reader (②) or picking one from the list (③). When the barcode reader is used, corresponding patient is highlighted in a list (④). Once the patient to consult is identified, selection on the patient entry leads the application to the *Clinic* UI in Figure 8(a).

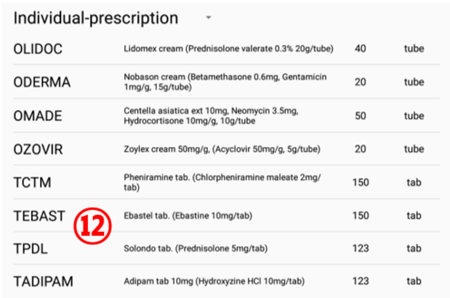


(Figure 7) Patient consultation waiting list



(Figure 8) (a) Patient consultation UI for PP (predefined package prescription)

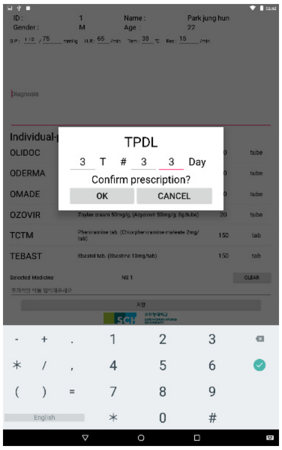
In Figure 8(a), doctors can see the patient information (①) and can register vital signs of the patient (②). Symptoms and opinions can be entered as in a normal HIS system (③). In ④, doctors can select one from three menu items. They are pre-defined package prescription (PP), individual prescription (IP), and miscellaneous prescription (MP). Once PP is selected, the list of PP will be displayed in ⑤ and the details of the medicine that compose the PP will be displayed in ⑥. In this Figure, we see 8 predefined prescriptions (GI1, MP1, MP2, PS1, PS2, ANTI15, PS10, DT10). Stock count of the medicine (⑦), measuring unit (⑧), is also provided, so that doctors can make prompt prescriptions. The selections are accumulated in ⑨. Doctors can review the prescription and make amendment (⑩), and may give remarks to the pharmacist (⑪).



(Figure 8) (b) Patient consultation UI for IP (individual prescription)

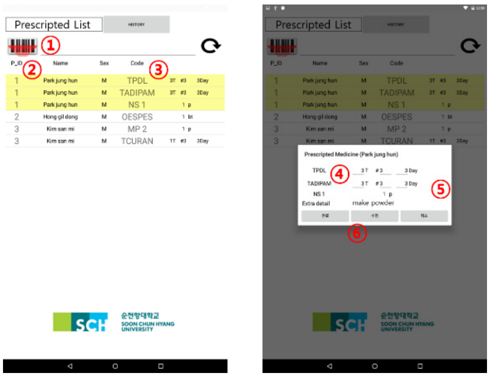
If we choose IP or MP from ④ of Figure 8(a), doctors can prescribe medicine individually. The difference between IP and MP is that IP is for the prescription-only-medicine and MP is for healthcare supplements such as vitamins. In these cases (IP or MP), doctors may enter the quantity and the medication instruction on the prescription. Figure 8(b) is the IP display example. Here we see the list of medicines along with their types (⑫).

Figure 9 is displayed when the selection of the prescription (⑫) in Figure 8(b) is made. Here, doctors can see the name of the medicine and may enter the medication instruction. If the type is pack (p), tube (t), or bottle (bt), the unit is count, and no further instruction is needed. For capsules (cap) and tablets (tab), doctors can give medication instruction using the format 'aT #b cDay'. This indicates taking 'a' amount of pills per day, dividing them into 'b' time per day, and take it for 'c' days. So, the total number of pills to give out is a×c. For example, if the memo is '4T #2 3Day' this indicates that, "for one day, take 4 pills dividing them into two times, for 3 days." So, the count of pills to give out is 12. This is a commonly used medication instruction format of the hospital.



(Figure 9) Medication instruction entry UI

After the consultation, doctors can give orders for lab test or surgery by using the button ⑬ in Figure 8(a). Once the button is selected, we get a new dialog where we can specify the type and the body region of the lab test. Similarly, details of the surgery can be specified and handed to the doctors in the surgery room. With the information passed, doctors at the surgery room check patient's medical record, and make a surgery plan and arrangement.

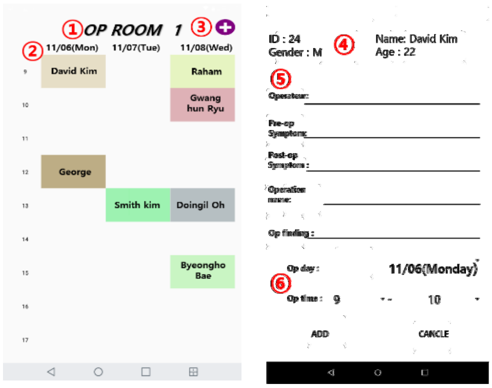


(Figure 10) Pharmacy UI

Figure 10 is the UI at the pharmacy (medicine dispensary unit). We get into this UI by selecting pharmacy button (③) in Figure 6(a). When a patient goes to the pharmacy, the barcode on the wrist-band is to be read (①), and the corresponding prescription is to be highlighted (②). If the patient has multiple prescription, all of them are highlighted. Since name of patient and medicine and medication instruction are all displayed in a compact fashion, a prompt preparation of the prescription is possible (③). When the pharmacist gives out the medicine, double checking on the name of the patient, medicine name, and medication instruction (④) are possible.

Below the information is a remark that the doctor gives out to the pharmacist, so that special conditions of the prescription can be considered (⑤). For the health supplement prescriptions, such as vitamins, pharmacists can enter their own give-outs by selecting (⑥), and by entering the corresponding information in the dialog.

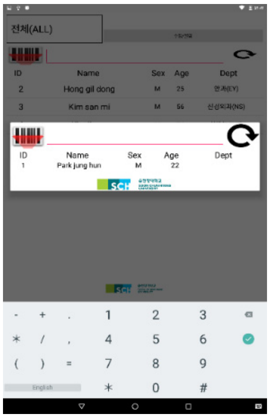
When medicines are given-out, stock counts are re-calculated, and it will be applied to the DB in real-time, so that the over-prescription of the out-of-stock medicine would be automatically blocked.



(a) Surgery schedule (b) Surgery registration
(Figure 11)

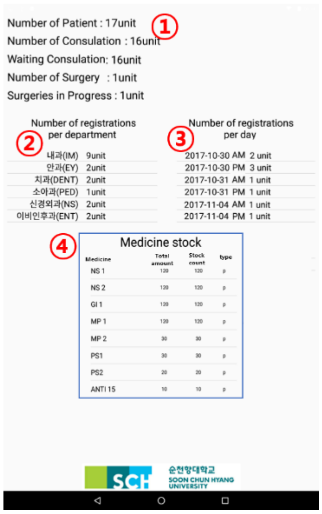
We get into the Figure 11(a) form, when we choose *Surgery* from Figure 6(a) main UI. Here, we get the information of each surgery rooms. The information includes, surgery room number (①), and surgery schedule of the room (②). Once the patient arrives to the surgery reception, another admission is required. The admission is possible by pressing button ③, and it will give us a list similar to the consultation waiting list in Figure 7. Doctors can pick the patient from the list and enter the information related to the surgery in Fig 11(b). Doctors can see the patient information (④). Once the condition and the surgery body region of the patient is examined, doctors enter surgery related patient information

(⑤). A schedule of the surgery can be set by entering date and time of the surgery (⑥).



(Figure 12) History Functionality

For the patient list in the Clinic UI (Figure 7) and Pharmacy UI (Figure 10), there is a history functionality, so that the user can make amendment to the patient information. Figure 12 shows the form that we can search for a particular patient and make amendment for wrong consultation entry or prescription.



(Figure 13) Statistical data display

Finally, Figure 13 is the statistical data display UI. We get into here when we choose ⑤ from the main UI (Figure 6(a)). From the display ①, we get 1) number of patients registered, 2) number of consultation, 3) awaiting consultations. From ②, we can find out the consultation counts for each departments, and from ③ the number of consultations for the each day and session (morning and afternoon). We can also see the stock counts of medicines in a Listview (④).

5. Conclusion and Future Research

In this paper we proposed a mini OCS system that can be used in an outdoor wireless communication environment. The system is named SCH-mOCS, and it is developed to serve patient better and faster without the use of paper charts. More accurate medicine dispensary and better medicine stock counts can be maintained with SCH-mOCS. In addition, we can accumulate important patient medical record that we may use as big data to give better knowledge about the patients in the serviced region.

In the future development, we are going to integrate the system with medical devices such as the blood-pressure machine so that the implementation can give better and more accurate vital records of the patient. We are also going to apply SCH-mOCS in many real domestic and foreign voluntary medical services. With the fine tuning and adoption of further user requests, we hope the system be a real world product that can better serve the needs for the challenged.

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