

**Providing Personal Health Records in Malaysia**  
**- A Portable Prototype**

by

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## ABSTRACT

Many of the current Malaysian healthcare information are still paper-based and standalone. Majority of the stand-alone systems which used to handle medical information systems do not utilize the Internet or any other real time technologies. Although there is several health information systems used in some of Malaysia s hospitals, none of these information systems handle health records. The progress of Health or Hospital Information Systems (HISs) has been very slow, and it is unlikely to increase much in the future.

Health records are used to store individuals health data, the data can be important at the time of need. Data management is an important step in maintaining health records but current data health management of healthcare systems in Malaysia is ineffective. Health data are scattered around health providers such as private clinics or government hospitals, individuals are unable to access their complete health records. Without a complete health record, medical officers are unable to grasp the full picture of individual s health, which lead to medical errors, drug interactions and unnecessary tests.

Even with electronic health records, they are usually maintained in a computer with Internet connectivity. Countries like Malaysia have a lot of rural areas without internet access and computers are not that common to the people living in rural areas. However, a cellphone is a common device which is not only owned by many people living in Malaysia, but all around the world.

PPHR (Portable Personal Health Record) is an application that can be installed in a cellphone and it is designed to manage personal health records. Extensions of the PPHR such as improving the accessibility, availability and usability have been made in this research to focus on Malaysian residents.

This dissertation describes the importance of having a portable personal health record and proposes a solution to it. Design considerations are clearly stated and solutions meeting these considerations will be explained in details. This dissertation will also review the outcomes of the evaluation which is important to find out whether PPHR is useful and also the level of concern of individuals in Malaysia with regards to their health data.

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## DECLARATION

I hereby declare that the dissertation *Providing Personal Health Record in Malaysia A Portable Prototype* is my own work and that all the sources I have used or quoted have been acknowledged by means of complete references.

It has not already been accepted for any degree, and is also not being concurrently submitted for any other degree.

Signature:

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## Introduction

### 1.1 Problem Statement

Many of the current Malaysian medical information systems are paper-based and are stand-alone systems that do not utilize the Internet, multimedia, wireless or any real time technologies. (Shihab et al. 2007)

Malaysia has a health data collection problem. As yet, there is no unified system of universal access to healthcare for every Malaysian citizen. The progress of Health or Hospital Information Systems (HISs) has been very slow, and it is unlikely to increase much in the future. An affordable alternative solution is to encourage the implementation of personal digital health records. Personal Health Record (PHR) systems are an increasingly popular approach to maintain an individual's health data. Nowadays most PHR systems are based on World-Wide Web (WWW) technology.

The proposed research will focus on developing a mobile or portable extension to Web-based PHR systems. The main aim of this research is to incorporate real-time mobility technology to offer maximum availability of Personal Health Records in Malaysia. Individuals shall be able to participate in PHRs without broadband, as it is still not yet widely available in certain regions of Malaysia like Sarawak. A mobile personal health record called the Portable Personal Health Record (PPHR) will be the outcome of this research. Data is kept in a mobile phone so that it can be carried around the world. The data will be backed up on a web database. The prototype for the proposed system will be implemented using open source tools.

### 1.2 Personal Health Records

#### 1.2.1 What is a Health Record

Health records may include a whole range of data in comprehensive or summary form, including demographics, medical history, medication and allergies, immunization status, laboratory test results, radiology images, billing information (HIMSS 2009).

### **1.2.2 What is a Personal Health Record?**

The PHR is an obscure concept which has been developing over several years. The term has been applied to both paper-based and computerized systems. PHR can be found on several platforms including paper-based, pc-based, internet-based, mobile Smartphone-based and portable-storage platforms. However, current usage usually implies an electronic resource. In recent years, several formal definitions of the term have been proposed by various organizations. (Munnecke 1999) (Pubmed 2004) Although there are a lot of different definitions, most of them agree that the Personal Health Record stores an individual's personal health information and individuals are free to choose what information is to be included in the report. It is a combination of information by professionals and non-professionals.

Personal Health Records are different from Electronic Health Records. Electronic Health Records are usually designed for use by health care providers. The data of Electronic Health Records are legally mandated notes on the care provided by clinicians for patients. The same can be said for data recorded in paper-based medical records. There is no legal mandate that compels patients to store their health information in Personal Health Records.

PHR has its own disadvantages, such as information inaccuracy or insufficiency. Contents of the PHR should be taken into consideration to form a useful record not only for the individual but also for doctors or clinicians.

### **1.2.3 Importance of Personal Health Records**

A patient's health information could be scattered across many different health care providers, facilities, and possibly even somewhere online (AHIMA 2009). Personal health records enable patients to store their health records collected anywhere and organize all the data into a piece of updated information. Personal Health Records can include any information about a patient's health, especially information that his/her doctor may not have, such as exercise routine, hereditary illnesses, or changes in dietary habits. Hospitals usually need a few key facts to give patients the fastest and best care in an emergency situation such as medication, allergies (especially to drugs), and emergency contact information (U.S. Department of Health & Human Services 2009). If a PHR is with the patient, the patient can establish special permissions to

allow others to have access to it so that they can have this critical information which may save the patient's life.

## **1.3 The Current Problem - Healthcare and Health Records in Malaysia**

### **1.3.1 History and Background**

Healthcare in Malaysia is mainly the responsibility of the Ministry of Health. Malaysia generally has an efficient and widespread system of healthcare; it has a dual-tiered healthcare system where one party is a government-led and government-funded public sector while another one is a private sector (David 2009). The public sector is almost entirely funded by budget allocations. Patients pay low fees for access to both outpatient treatment and hospitalizations. The public sector caters to the bulk of the population at 65% but is only served by 45% of all registered doctors, and even fewer specialists (25%-30%) (David 2009). Doctors are required to perform 3 years of service with public hospitals ensuring adequate coverage of medical needs for the general population.

The private sector on the other hand, has grown over the past 25 years. The majority of private hospitals located in urban areas lack the latest facilities, unlike the public hospitals which are equipped with the latest diagnostic and imaging facilities (UNICEF 2009). Private hospitals are not generally seen as an ideal investment as it has often taken up to ten years before any company sees any profits out of it. However, the situation has now changed especially in view of the increasing interest by foreigners to come to Malaysia for medical care, and the recent government focus to develop the health tourism industry (nHealth Tourism 2009). Private hospitals are starting to grow, and since health tourism is focus of the government, healthcare quality and efficiency has become a vital issue.

### **1.3.2 Today's Healthcare**

The Fourth Prime Minister of Malaysia, Tun Dr. Mahathir Mohamed (1991), mentioned:

By the year 2020, Malaysia is to be a united nation with a confident Malaysian society, infused with strong moral and ethical values, living in a society that is democratic, liberal and tolerant, caring, economically just and equitable,



progressive and prosperous, and in full possession of an economy that is competitive, dynamic, robust and resilient.

In Seventh Malaysia Plan, it was stated that there will be 33 paperless public hospitals in Malaysia. There will be 8 hospitals using the Total Hospital Information System (T.H.I.S), while the another 25 smaller hospitals will use the Hospital Information System (H.I.S). Due to the economic crisis in 1998, those projects were put on hold, and are expected to be implemented during the Eighth Malaysia Plan (Wetzel 2003). Now in the early stage of The Ninth Malaysian Plan, only a few hospitals are known as paperless hospitals, while other hospitals are still on hold. Some of the hospitals are not fully operational because they are still testing the systems.

#### ***1.3.2.1 The Ninth Malaysia Plan***

The Malaysian government heavily subsidizes public healthcare. Currently almost 6.5% of the GDP is allocated to the healthcare sector. According to the Ministry of Health Malaysia (MOH 2004), basic health care through static health facilities is currently available to and accessible within 5km for more than 93% of the population of Peninsular Malaysia, 76% in Sabah and 61% in Sarawak. This coverage does not include the non-static health facilities such as the flying doctor squad and mobile health teams.

During the Ninth Malaysia Plan, the government will consolidate health care services, enhance human resources development and optimize resource utilization. Delivery systems will be improved with greater involvement of the private sector and Non-Government Organizations (Ahmad 2008). Computerization and networking has brought Malaysia into monitoring and analysing information on local health data, increasing demand for health tourism, the need for hospitals to upgrade their healthcare services to meet international standards. The increasing pressure on the government to upgrade the healthcare industry is one of the driving factors for adopting automation in the healthcare industry. Healthcare information systems are required for timely, accurate and user-friendly evidence based decision making. However, it has limited ability to identify, monitor, access, analyse and utilize data for planning and decision-making. Therefore, the challenge is to have in place a strategic plan to ensure integrated data from both the public and private sectors. This will enhance the ability of the national healthcare system to effectively respond to public health challenges.

During the Ninth Malaysia Plan, electronic health will continue to leverage on wireless and high-speed communication networks, interlinking various medical institutions across geographical and spatial boundaries (Ahmad 2008). This will increase health information sharing, optimizing specialist resources and facilitating data management.

#### ***1.3.2.2 Drawbacks of Current Healthcare System***

Since many of the current Malaysian healthcare, medical information and emergency systems are still paper-based and stand-alone there will be drawbacks to such systems. Some important drawbacks (Shihab et al. 2007; Warner n.d.; The Star Online 2004) include lack of a global shared system used by healthcare centres. Some medical centres that use electronic medical storage systems for storing patients record are windows-based and lack utilizing open source software, which results causing a lot of money when maintaining the systems. There is also lack of supporting multimedia environment, real-time and mobile technology. Integration between medical and emergency systems does not usually happen.

#### **1.3.3 Medical Records Kept by Healthcare Providers**

Currently in Malaysian hospitals, health records which are not special cases, e.g. cases that do not need to be followed up on by a specialist, are allowed to be owned by individuals and treated as a PHR. For the specialized case health records which are owned by the healthcare provider, patients are allowed to request for a summary of their health information. The summary of the information may not be sufficient for the medical officer to fully analyse patients health status.

The above statements about how patients obtain their health records are supported by the interview with Mr. Ngui How Cheng in Sarawak General Hospital on 15/12/2009 (See Results section). According to Mr. Ngui, in hospitals or clinics which do not use HIS that can handle health records, the records are kept in physical folders like a cardboard folder holding sheets of paper. These folders are all kept in a cabinet or specific store. Madam Goh Teck Wang (See Results Section), who was a nursing sister for more than 30 years working for Sarawak General Hospital, Sibul General Hospital, London Fertility Clinic, Kapit General Hospital and Sibul Poliklinik, says that even the summaries written by the specialist for the patient only consist of the latest information but none older than that. This means that the sufficiency of the information is only decided by that one specialist, and if the patient has a long history, the other doctors might miss out a lot of important information about the patient.

**Figure 1-1: The School Health Records**

Source: (MOH 2009b)

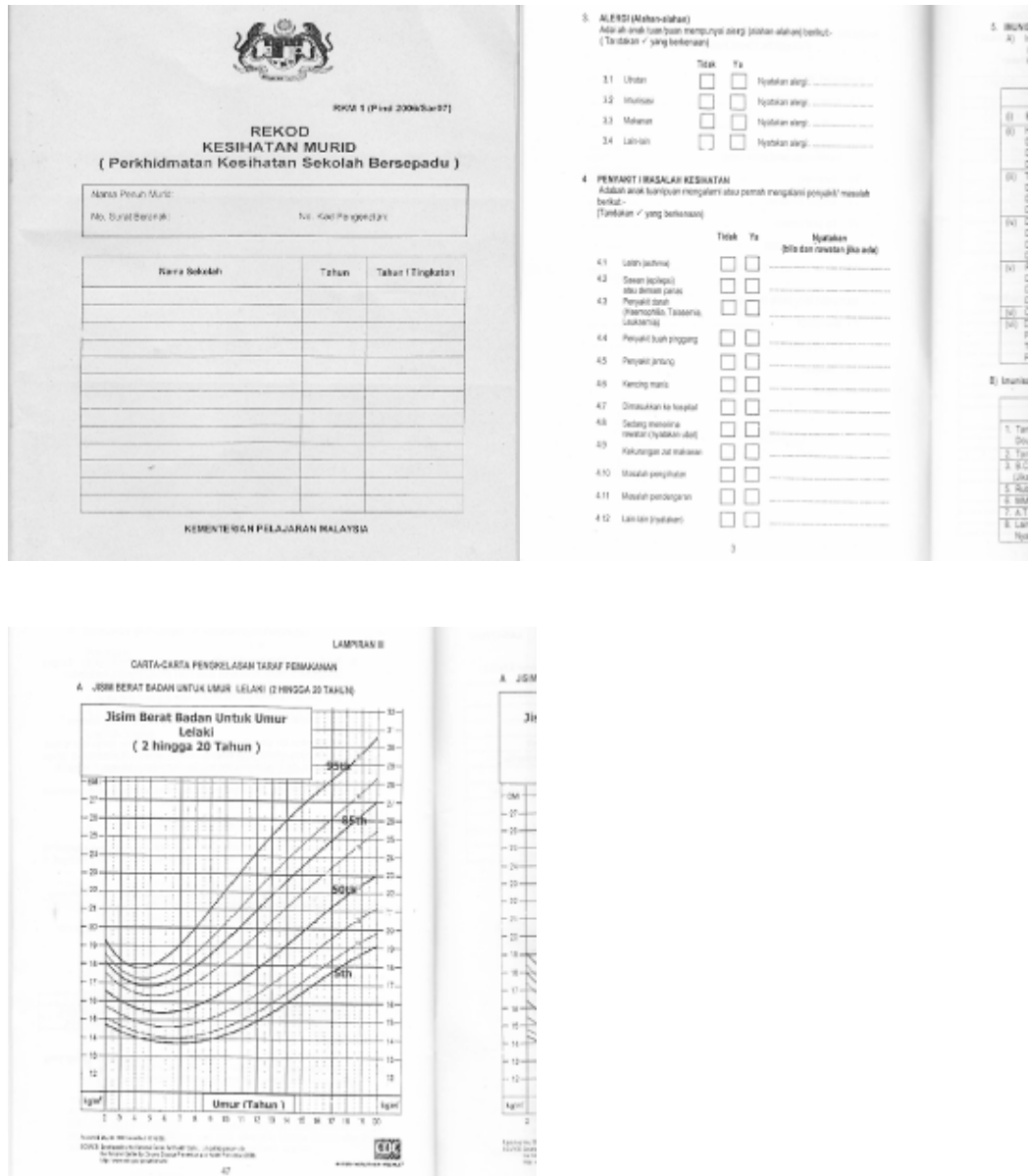


Figure 1-1: Schools students health record which is kept by the clinic responsible for the corresponding school. This record is not maintained individually and neither students nor their parents can keep the record or bring it elsewhere.

**1.3.4 Medical Documents Kept by Individuals (Personal Health Records)**

Currently Malaysia's Medical Documents are all paper-based. The figures below are medical documents used by healthcare providers in Malaysia.

**Figure 1-2: Medical Card**

Source: (SGH 2009b)

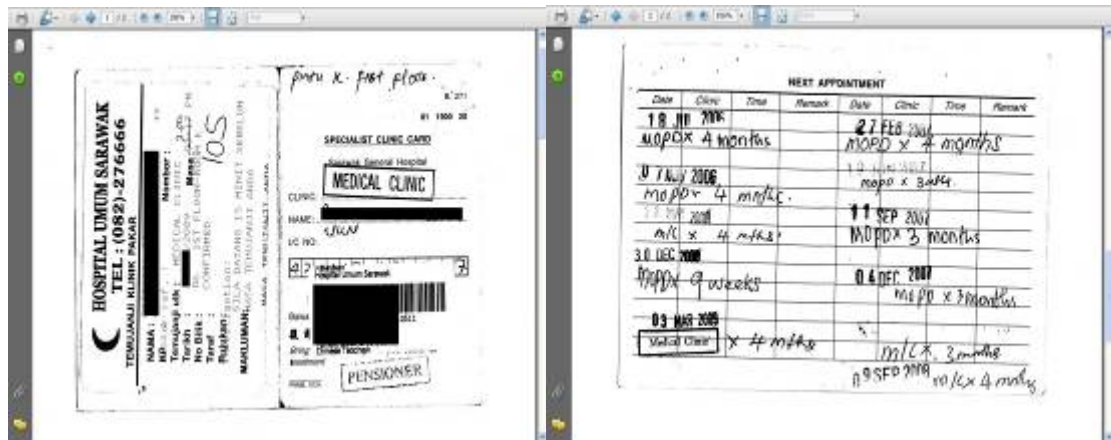


Figure 1-2 is a sample medical card used at the Sarawak General Hospital. This medical card specifies the date of a patient's past and next appointments or visits. After a patient is consulted by a doctor or specialist, a medical assistant will then write down the date of next visit decided by the corresponding doctor. The patient then needs to hand over the card to a counter where the patient's appointment is processed. If the date of the planned appointment is available, a confirmation date will be printed on the front page of the medical card. Pharmacies also use this medical card to decide how much medication should be provided to the patient based on the time of the next visit. Figures below show various types of Health Record of Malaysia Healthcare Providers.

**Figure 1-3: Children Health Record**

Source: (MOH 2009a)

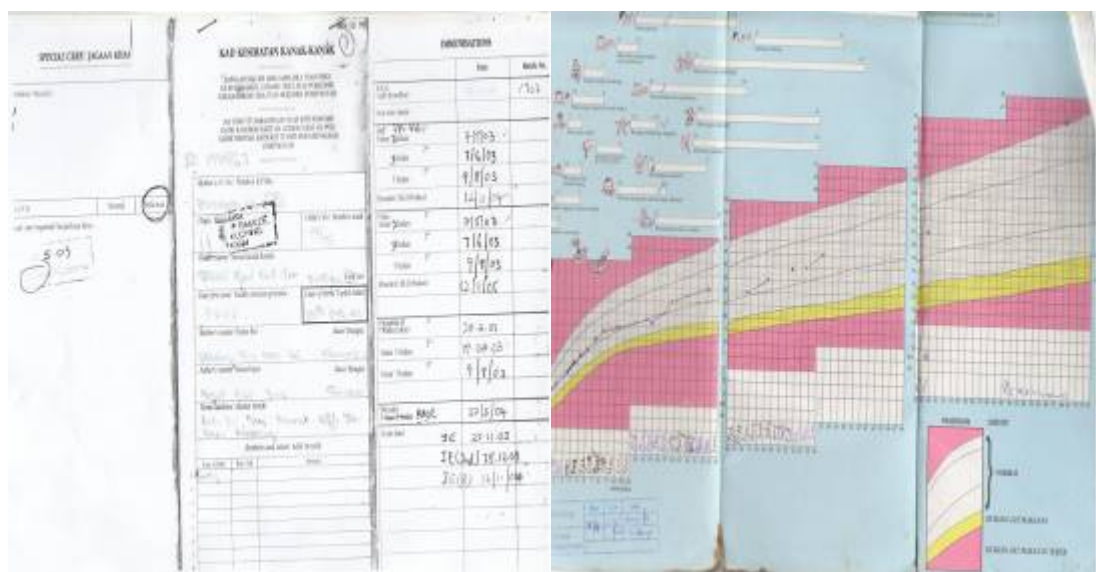


Figure 1-3 is child health record under age of 7. This report is important for people who want to migrate to another country. As shown, the details written in the record are messy, confusing, and also hard to read.

**Figure 1-4: Blood/Urine Test Paper**  
Source: (SGH 2009a)

The image shows a medical test paper form with the following sections and fields:

- Header:** 19112010 (Fasting)
- Administrative Information:**
  - 1. Nama: [Redacted]
  - 2. No. Rawat: [Redacted]
  - 3. Lincas: [Redacted]
  - 4. No. Bilik Rawat: [Redacted]
  - 5. No. Pendaftaran: [Redacted]
  - 6. Jenis Bilik: [Redacted]
  - 7. No. Pendaftaran: [Redacted]
  - 8. No. Pendaftaran: [Redacted]
  - 9. No. Pendaftaran: [Redacted]
  - 10. No. Pendaftaran: [Redacted]
- Medical Information:**
  - 11. No. Pendaftaran: [Redacted]
  - 12. No. Pendaftaran: [Redacted]
  - 13. No. Pendaftaran: [Redacted]
  - 14. No. Pendaftaran: [Redacted]
  - 15. No. Pendaftaran: [Redacted]
  - 16. No. Pendaftaran: [Redacted]
  - 17. No. Pendaftaran: [Redacted]
  - 18. No. Pendaftaran: [Redacted]
  - 19. No. Pendaftaran: [Redacted]
- Test Results Section:**
  - 19.1. Bilik Rawat: [Redacted]
  - 19.2. Bilik Rawat: [Redacted]
  - 19.3. Bilik Rawat: [Redacted]
  - 19.4. Bilik Rawat: [Redacted]
  - 19.5. Bilik Rawat: [Redacted]
  - 19.6. Bilik Rawat: [Redacted]
  - 19.7. Bilik Rawat: [Redacted]
  - 19.8. Bilik Rawat: [Redacted]
  - 19.9. Bilik Rawat: [Redacted]
  - 19.10. Bilik Rawat: [Redacted]
  - 19.11. Bilik Rawat: [Redacted]
  - 19.12. Bilik Rawat: [Redacted]
  - 19.13. Bilik Rawat: [Redacted]
  - 19.14. Bilik Rawat: [Redacted]
  - 19.15. Bilik Rawat: [Redacted]
  - 19.16. Bilik Rawat: [Redacted]
  - 19.17. Bilik Rawat: [Redacted]
  - 19.18. Bilik Rawat: [Redacted]
  - 19.19. Bilik Rawat: [Redacted]
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  - 19.74. Bilik Rawat: [Redacted]
  - 19.75. Bilik Rawat: [Redacted]
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  - 19.81. Bilik Rawat: [Redacted]
  - 19.82. Bilik Rawat: [Redacted]
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  - 19.92. Bilik Rawat: [Redacted]
  - 19.93. Bilik Rawat: [Redacted]
  - 19.94. Bilik Rawat: [Redacted]
  - 19.95. Bilik Rawat: [Redacted]
  - 19.96. Bilik Rawat: [Redacted]
  - 19.97. Bilik Rawat: [Redacted]
  - 19.98. Bilik Rawat: [Redacted]
  - 19.99. Bilik Rawat: [Redacted]
  - 19.100. Bilik Rawat: [Redacted]

Figure 1-4 is a blood/urine test paper. There is a section in the hospital for urine and blood test. The paper specifies the date of test and whether to fast or not the night before the test. On the chosen date, the patient shall hand in this test slip and queue up for their turn to have the test; the result of the test will be sent straight to the corresponding patient's record, included in the patient's health record to be reviewed and consulted by doctor on the date of next visit.

### 1.3.5 Health Records Issues in Malaysia

#### 1.3.5.1 Communications between Rural and Town Areas

Most of the rural areas, especially in Sarawak, do not have Internet services. According to Mr. Ngui How Cheng, the current communication solution used in rural areas is by satellite. The limitation of transmitting data through satellite is that it is easily influenced by bad weather; transmission signals are bad when it is raining. This situation prevents patients or doctors in rural areas from accessing information anytime they want. There are two monsoon winds that influence the rainfall at different intervals of the year in Malaysia. Malaysia is a country where it usually rains a lot. The weather in Peninsular Malaysia is affected by monsoon wind that blows from South China Sea and the Straits of Malacca. The northeast monsoon blows winds from the South China Sea from

November to March, which is five months, and this is the time when east coast states experience heavy rainfall (MITRE 2006). As the monsoon winds are particularly strong, it also brings heavy rain to the west side of Peninsular Malaysia sometimes. The west coast of Peninsular Malaysia is affected by the southwest monsoon that blows the winds from the Straits of Malacca during the months of May to September (MITRE 2006). The periods between the monsoons are usually marked by heavy rainfall. With weather in Malaysia being what is describe above, transmission of healthcare data via satellite is not very ideal, as rainfall will pose a problem in obtaining healthcare information by individuals or healthcare providers.

#### ***1.3.5.2 Interoperability***

Interoperability among different organizations or healthcare system is crucial as there often are cases in which there are multiple ways to model the same information (MITRE 2006). Interoperability only exist if a communication medium exist, it provides the ability to exchange records across medical institutions. If a system lacks interoperability, the consequences will be a lot of time wasted in manually entering data from an external system. In Malaysian healthcare systems, as mention above, there are different Health Information System in use, due to the reason that the healthcare providers commonly select different systems to meet the information needs of individual departments or facilities. How does information residing on disparate computer systems talk to each other if interfacing the systems which may be built on different platforms, using different programming languages and different data format. Use of standards and coding systems is vital to increase interoperability. In healthcare informatics, a standard defines a commonly agreed upon way to collect, maintain, or transfer data (Gretchen et al. 1999).

As Electronic Health Records develop, the demand for consistency in communicating and exchanging clinical information grows. To make health and clinical data from multiple sources yield a longitudinal record requires that the vocabularies used in the records at their source be standardized (Gretchen et al. 1999). Standards and coding systems will be discussed in more detail later.

#### ***1.3.5.3 Telehealth Projects***

The Malaysian Ministry of Health (MOH) has always treated healthcare quality as an important issue. One of the actions taken by MOH to increase the quality of healthcare in Malaysia was through Telehealth projects. The Telehealth model consists of four

pilot projects which are Customised/Personalised Health Information and education, continuing Medical Education, Teleconsultation and Lifetime Health Plan (Abidi et.al. 1998; Abidi and Zaharin 1999). Electronic Health Records play an important role in these projects by providing patients health history. However, these projects were never implemented on a large scale.

## 1.4 Approach to a Solution - Electronic Health Records and Systems

The majority of healthcare providers are under the Ministry of Health. The table below shows the number of units of healthcare facilities in Malaysia under Ministry of Health. This information is provided by the Ministry of Health and Telehealth Unit(MOH 2003, 2004; Hissan 2006; Annie et al. 2008; WHO 2006).

**Table 1-A: Healthcare providers in Malaysia**

Total number of:	Unit
MOH hospitals	135
Beds in MOH hospitals	30,969
Special medical Institutions in MOH	6
Bed in special medical institution(MOH)	4,740
Non-MOH Government hospitals	6
Beds in non-MOH government hospitals	2,916
Private hospitals, maternity/nursing homes	222
Beds in private hospitals	10,794
MOH dental clinics	2,047
MOH dental chairs	3,407
MOH health clinics	809
MOH rural clinics	2,965
MOH maternal & child health clinics	88
MOH mobile Clinique	151

## Health Human Resource

Total number of:	Private	Public
Doctors	13,335	9410
Dentists	1,368	1,572
Pharmacists	889	3,403
Nurses	34,598	13,044
Medical assistants	7,150	570

Tables 1-A: show the total of health facilities and human resources available in Malaysia. Among these health care providers, there are only a total of 131 healthcare providers adopting ICT in healthcare (MOH ICT Conference 2009). This shows how insufficient the use of Information Systems is in Malaysian healthcare. Currently there are six different HIS (Hospital Information System) adopted by healthcare providers in Malaysia which will be discussed, only one of them, Teleprimary Care, is used most widely compared to the other five. It contains the most number of modules and has won three awards. (Hissan 2006; MOH ICT Conference 2009; Brilliance Information 2005) Teleprimary Care will be discussed in more detail.

### 1.4.1 Electronic Health Records

An electronic health record (EHR) is an evolving concept defined as a longitudinal collection of electronic health information about individual patients or populations. (Gunter and Terry 2005)

The electronic Health Record (EHR) is a longitudinal electronic record of patient health information generated by one or more encounters in any care delivery setting. (HIMSS 2009)

The aggregate electronic record of health-related information on an individual that is created and gathered cumulatively across more than one health care organisation and is managed and consulted by licensed clinicians and staff involved in the individual's health and care (NAHIT 2009)

From the three statements above, we know that the main functionality of an electronic health record is to store a collection of patients health information electronically.



#### ***1.4.1.1 Why make Health Records Electronic?***

Electronic records are superior to paper records because they decrease error caused by handwriting problems and ease physical storage requirements (Julia et al. 2003). On the other hand, health records can be searched for faster and easier as there is no need to search through physical cabinets for files and papers. If it is handled electronically, there is also a chance that it can be obtained from anywhere in the world if it is available for access from the internet or other communication mediums.

#### ***1.4.1.2 Issues with Electronic Health Records***

Data management is an important step in maintaining health records. As found in this research, current data management of healthcare systems in Malaysia is ineffective. Effective data management should be able to maintain data availability and accessibility.

Data accuracy could also be an issue, but within the framework of PHRs we have little control over user input and its accuracy. In order to improve data accuracy, standard codes such as SNOMED-CT can be added when the data is uploaded online. Use of standard codes would reduce the variability in the way data is encoded for clinical care. This would be true for all Personally Controlled Health Record systems.

#### ***1.4.1.3 Data Availability***

##### ***1.4.1.3.1 Problem:***

There are general hospitals owned by the Malaysian Government and there are many private clinics owned by individuals. These clinics do not share patients health records with one another or general hospitals. This issue has caused difficulties in locating patients health information when it is needed. Healthcare providers do not usually give out patients health record, as the record is owned by the provider, instead of the patients. As a result, patients who have different healthcare providers are not able to share their medical history with their current healthcare provider.

##### ***1.4.1.3.2 Consequences:***

Lack of data availability might require a large amount of time for the current doctor to investigate the patient's current health condition especially when the patient has a lot of health issues. On the other hand, a lot of procedures such as urine tests and blood tests might need to be repeated as the patient may not be able to obtain previous results. This causes a waste of time and money, also risking the health of patients if the patient needs to be given immediate medical treatment.

#### 1.4.1.3.3 Solution:

Having a personal health record that can be carried around the world, for example stored in a mobile device such as a cellphone, could be an ideal solution to maximize availability of health data. The aim of this research outcome is to enable health records to be stored on a mobile phone and the health data can be backed up through the most widely covered communication medium, GSM (Global System for Mobile Communications). The data will be stored on a web database, e.g. Google Health.

#### *1.4.1.4 Data Security vs. Accessibility*

The objective of security is the ability to prevent undesired access while still allowing authorized access to information. Accessibility vs. security is a well-known dilemma. It is difficult to decide where to draw the line between what could be considered secure and what could be considered accessible. Higher accessibility might lead to less security. Almost every mobile phone has a security feature with which users can lock the phone from being used with a digit password. This automatically brings in a security feature for the PPHR as different individuals will need to have the phone unlocked first before they can access the PPHR.

In order to ensure confidentiality and protection of health records that are stored on a web database, a database which is protected by the Health Insurance Portability and Accountability Act (HIPAA) will be treated as a prime choice. For now, both Google Health and Microsoft HealthVault do not follow the HIPAA but they allow users to control who sees their information and will not sell, rent, or share information with others unless the users specifically authorize the dissemination of information (Caldarella 2010).

The proposed PPHR is not only for the user's usage but also for medical assistants. Medical assistants should be able to have access to user's health data especially if the user is too sick to respond or is unconscious. If the phone is locked, medical assistants will not be able to access the user's health records unless the phone password is given specifically to the medical assistant.

## **1.4.2 Current Health Information Systems (HISs) in Malaysia**

### ***1.4.2.1 Teleprimary Care (Teleprimarycare 2008)***

As its name says, TPC is not really a HIS. Its purpose is to link small rural clinics to larger centres for consultation. TPC is a healthcare management IT solution which links primary to secondary healthcare (health clinics to hospitals) (Hissan 2006). It is fully owned by Ministry of Health Malaysia, but was created and continues to be managed by a private vendor. TPC is being implemented in 5 states, namely Johor, Sarawak, Perlis, Selangor and WP Kuala Lumpur at the Health Clinics, District Health Offices, and Pejabat Kesihatan Bahagian (Sarawak) which totals to 73 Health Clinics (MOH ICT Conference 2009). However, as of 2009 the MOH wants to install TPCs in larger hospitals.

It is not known how TPC handles health records. As with most HISs, the records are not available to the patients themselves.

According to the MOH Malaysia (Teleprimarycare 2008), TPC has one of the best rural health services in the world. TPC has contributed a lot in Teleconsultation to the rural areas. The Director-General of Health Tan Sri Dr Ismail Merican said with TPC, patients in rural areas can now have access to health information so that they can be treated instead of coming to hospitals for minor ailments (Annie et al. 2008). According to the New Straits Times (Annie et al. 2008), doctors and specialist get online access to the diagnosis and medical history of patients who they may never see in person. Health record management is not available on this system. Since then, Personal Health Record (PHR) is not yet available for the residents in the rural area healthcare providers which use TPC.

### ***1.4.2.2 CIS (Clinical Information System)***

CIS consists of 10 modules and is only implemented in Putrajaya Health Clinic (MOH ICT Conference 2009). The main features of CIS (CIS 2009) include developing and deploying electronic health records (EHRs), use of regional and national health information exchanges (HIEs), providing access and control of individual health information using PHR and HIE-related technologies by individuals and enabling population health by connecting clinician s data to quality and public health initiatives (Northrop Grumman 2009). Despite the advertised PHR in CIS, it does not appear to be implemented. According to Mr. Ngui How Cheng (personal communication 15/12/2009 - refer to Results section), PHRs retrieved electronically are not available

yet in Malaysia. Additionally, CIS is only used by one clinic in Malaysia, so basically PHR accessibility and availability cannot be considered to exist in Malaysia.

#### ***1.4.2.3 OHCIS (Oral Health Clinical Information System)***

OHCIS is implemented in the Malaysian states of Johor and Selangor with a total of 11 clinics using it. It consists of 9 modules which are patient management system, appointment, patient notes, dental laboratory, school health, etc. (MOH ICT Conference 2009). OHCIS, like the others, does not provide availability of oral health records.

#### ***1.4.2.4 Total Hospital Information System (THIS)***

According to the information provided at the MOH ICT conference (MOH ICT Conference 2009), five hospitals are using THIS. In electronic healthcare, the use of Information Technology in the health sector aims to attain the concept of patient accessing the care needed at one point of contact rather than having the patient referred to various levels of care (Mannaf 1996). THIS was implemented at the Selayang Hospital in 1999, followed by the Putrajaya Hospital in year 2000 (Hadis and Hashim 2004). There were 2 types of Hospital Information System (HIS) introduced: Intermediate Hospital Information (IHIS) and Basic Hospital Information System (BHIS) (Hassan 2004). According to Hassan (2004), hospitals that have more than 400 beds will be classified as THIS hospitals, less than 400 beds but more than 200 beds will be categorized as IHIS hospitals and less than 200 beds will fall into BHIS type hospitals.

A study by Mohd and Syed Mohamed (2005) found that some of the problems related to the software provided from different vendors are unsolved because every vendor has its own expertise. On the other hand, EMR (Electronic Medical Record) as a core component of THIS, user acceptance level of EMR systems using THIS in hospital are moderately accepted, a generic design of EMR system is required.

#### ***1.4.2.5 Sistem Pengurusan Pesakit (SPP)***

SPP is adopted by Hospital Seremban and Hospital Port Dickson (MOH ICT Conference 2009). SPP is owned by MOH Malaysia, the strength of SPP is enhancing the communication between clinics and hospital staff (MOH 2008). SPP contains a module that handles medical records, but it concentrates more on the computerized processing of reports; it is not internet-based to make records accessible to individuals.

#### ***1.4.2.6 PrimaCare in Malaysia***

PCDOM PrimaCare (PCDOM 2010) is an Electronic Medical Record & Clinic Management System that enables a general practitioner to comply with the Private Health Care Facilities & Services Act 1998.

It is a web-based client server system consists of following modules:

- Patient Management
- Clinic Management
- Pharmacy Management
- Schedule Management
- Medical Resources Management
- Billing Management
- Financial Management
- Asset and Supply Management
- System Administration

### **1.4.3 Alternative Solution - Personal Health Record (PHR) Systems**

Personal Health Record (PHR) or Personally Controlled Health Record (PCHR) systems have existed for about a decade. Almost all of them originated from and/or are based in the USA.

#### ***1.4.3.1 IndivoHealth***

Indivo (Indivo 2010) is an open source web-based system that enables an individual to own and manage a complete copy of health and wellness information. It is the original personally controlled health record system. Users can connect their records to third-party applications through Indivo to enhance the management and analysis of their health information.

#### ***1.4.3.2 Google Health***

Google Health (Google Health 2009) serves as a repository for web-users to store a variety of health-related personal information in a single place, and thereby functions as a one stop destination for accessing these crucial records in future. Google Health provides users with information on conditions, a merged health record, and possible interactions between drugs, conditions and allergies. Google Health is made available to its users free of cost.

Google Health's features include:

Allowing users to easily build online health profiles.

Assisting users to make quick search for doctors and hospitals.

Allowing users to import medical records from hospitals and pharmacies.

Allowing users to explore various health related issues and their treatments.

#### ***1.4.3.3 Microsoft HealthVault***

Microsoft introduced HealthVault (HealthVault 2010) which is a health application platform that lets consumers collect, store, and share health information online. The HealthVault platform provides a privacy-enhanced and security-enhanced foundation that can be used to store and transfer information between a variety of providers health services and health devices. Microsoft HealthVault is not a free cost application.

#### ***1.4.3.4 Advantages and Disadvantages of Existing PHR Systems***

All of the investigated PHR systems are web-based. Web-based PHR systems cover a wide area of usage as long as there is Internet service available. Massive information can be stored and access easily. The disadvantages of existing PHR systems include lack of accessibility to health information by residents living in rural areas. Most rural areas do not have an internet connection, even clinics or hospitals located in the rural areas are not able to obtain patients health information through the internet. In order for patients to maintain their own personal health records, they can only update health information in areas with internet available which is very inconvenient.

### **1.5 Extending PHRs to “Mobile Healthcare” or M-Health Systems**

M-Health broadly encompasses the use of mobile telecommunication and multimedia technology as they are integrated within increasingly mobile and wireless health care delivery systems (Istepanian & Lacal, 2003). It can be defined as mobile computing, medical sensor, and communication technology for health care (Istepanian, 2004).

#### **1.5.1 Reviews**

M-Health is most commonly used in reference to using mobile communication devices such as mobile phones and PDAs for health services and information. However, most M-Health systems are specialized for healthcare professionals but not the patients. This means that the health information will not be available to the patients wherever they are. Current M-Health systems usually require broadband access or wireless internet, which decreases the accessibility of health information especially in rural areas in Malaysia.

## 1.5.2 Examples

The systems listed below are a few popular M-Health systems inspected for this research. There are few differences between these systems and PPHR.

### *1.5.2.1 openRosa - JavaRosa*

JavaRosa (Dimagi 2010) is a project of Open Rosa, a member of the Open Mobile Consortium. It is an open-source platform for data collection on mobile devices. JavaRosa is based on the XForms standard which is the official W3C standard for next-generation data collection and interchange.

JavaRosa sends data to the central server while PPHR stores data on a cellphone.

### *1.5.2.2 SANA*

Sana (Sana 2010) is a student organization based at the Massachusetts Institute of Technology that offers an end-to-end system that seamlessly connects health workers to medical professionals. Sana application lets health workers run a procedure and collect patient data, Sana then uploads the information to OpenMRS (OpenMRS 2010) for a doctor to review. After reviewing the case, doctors can notify the health worker of the diagnosis by sending results to the Sana application. Similar to JavaRosa, Sana sends data to the central server; it does not have local storage. Sana is mainly used by health workers, PPHR is used by patients.

### *1.5.2.3 H'andy Sana 210 - Heart Suite*

H andy Sana (H andy Sana 210 2010) is a mobile phone which is currently offered by Medical Marketing Berlin. It represents a desirable new additional option for the care of patients. Heart Suite is an application designed for H andy Sana to keep track of health conditions. The major advantage of H andy Sana's Heart Suite is the ability to measure a patient's ECG, and it is possible for the patient to either save the recorded ECG or send it directly to their family doctor or any telemedicine centre. The user only needs to press two fingers on the phone's edges for 30 seconds for the phone to pick up, record and save their ECG. Additionally they can record and save other data such as blood pressure, blood glucose and cholesterol. The Heart Suite application is currently only available on H andy Sana 210, the only H andy model with the ability to measure ECG. A patient must own an H andy Sana 210 in order to use Heart Suite.

### *1.5.2.4 AirStrip*

AirStrip (AirStrip Solution 2010) is software developed by AirStrip Technologies, a medical software development company focused on enabling mobility in healthcare. The AirStrip Technologies platform provides healthcare professionals the ability to

remotely access virtual real-time waveform and other critical patient data direct from the hospital and send it to a handheld mobile device. Three main applications of AirStrip include:

- AirStrip OB mobilizes maternal/fetal waveforms (CTGs), annotations, exam status, medications, lab values, logistical information, and progress notes
- AirStrip CARDIOLOGY digitizes and mobilizes 12- and 15- lead waveforms and measurements
- AirStrip Patient Monitoring Health information include hemodynamic parameters, vital sign, vasoactive infusion, medications, allergies, demographics, I&O, lab results, and EMR data.

The main advantage of this application is that if a doctor is away from the hospital, the doctor will still be able to take part in critical care of a patient by virtually looking into the patient's room by using the application to keep track of patient's real time condition such as waveform data.

AirStrip accesses the internet to establish a connection with the hospital network to receive patient data. PPHR uses GSM instead, which is widely covers most places including rural areas. AirStrip currently only can be used on the iPhone, iPad, BlackBerry, Android and Windows Mobile Smartphone.

#### ***1.5.2.5 iPHER (Individual Personal Health Electronic Record)***

iPHER (Patient Practitioners 2010) is a small device which can be plugged into a computer using a USB drive. iPHER carries a unique Patient Practitioner's program. The Patient Practitioner's system is a self-contained medical record keeping database system. The patients are allowed to control the content of their health record and also input records in a format easily read by healthcare professionals. Most iPHERs are delivered as Open devices, which means everyone can access it as long as they have the iPHER device. For security reasons, iPHERs can be sold with biometric protection or dual password security. The Patient Practitioner program also offers a complete online backup system for all text records. Since the iPHER can only be read from a USB drive, health records can only be accessed with computers running the Windows™ operating system.

### **1.5.3 Relation of M-Health Systems to Personal Health Records**

Current M-Health systems are mostly written for healthcare professionals. Patients are unable to maintain their own health data. Most of the systems do not use GSM



connections, which mean that the health information will be unavailable and inaccessible for residents in rural areas. PPHR can be installed in most mobile phones including most old phones, but not for most of the current M-Health systems.

## **1.6 Health Record Visualization**

Patients can accumulate a massive amount of health information throughout their lives. In order to maintain this massive amount of health data, and at the same time navigate through the data fast and easily, various approaches can be used for electronic health record navigation. The intrinsic characteristic of a mobile device is to be small so that it can be carried around in a pocket or handbag. Mobile devices are more limited in terms of memory, battery power and screen resolution compared to computers. Although memory, power and screen resolution can be expected to be improved in the future, the screen size will not increase much to maintain the characteristics of a mobile device. Human computer interaction was concerned up to now on how to present information on screens which are large. According to Monique (2005), the quality of vision is due to the size and quality of the screens. For mobile devices, the bad quality of vision is due to the fact that users can get information on cellphones in areas which are not well suited for reading such as areas with bad lighting, bad posture or using one hand only sometimes. Visualization of data is one approach for summarizing information. Data visualization can be used to do view health records, but the limitation is so high that data representation cannot be adapted from a standard PC on to a mobile device.

### **1.6.1 Visualization Types and Techniques**

Visualization techniques are used to transform data into a cohesive visual representation so that it can be easily read by users and improve their understanding of the data. Data can come in different forms like scientific data, documents data, complex business data, gene information, protein structures, etc. Different types of visualization are used to present different types of data to achieve the best result. Visualization types include scientific visualization, business visualization and document visualization. Scientific visualization is the representation of scientific data graphically, allowing a researcher to gain insight into a system. Scientific visualization is applied on domains such as weather conditions, protein structures or temperature variation.

Business data visualization allows a user to analyse and present complex data in tangible form by recognizing the patterns and trends in large chunks of data. Visual

components such as charts, plots, histograms or trees are linked into one view of business data to answer targeted business questions. Multiple perspectives are linked together under a structured workflow to create analytical dashboards, and this allows business users to view their data in multiple dimensions (Ranjani et al. 2003).

A large document cannot be shown entirely to the reader due to the size of the display. If a user needs certain information from a document, the user might need to read the entire document, which is very inefficient. Filtering such information is very important. Document visualization presents the filtered information to the user in a way as to keep the context in view. Document visualization is usually used for documents with no specific patterns like scientific and business data. The success of document visualization depends on the simplicity of the presented view and the ability to be navigated easily.

There are several techniques used to visualize information, they are grouped in the following categories:

- Indented list
- Node-link and Tree
- Zoom-able
- Space-filling
- Focus + context or distortion
- 3D Information landscape

Methods grouped in one of these categories may have elements of the others; for example, Indented list may be Zoom-able too. This grouping was chosen as a starting point because each of these visualization techniques have characteristics that lead to different advantages and disadvantages.

### **1.6.2 Visualization Applications**

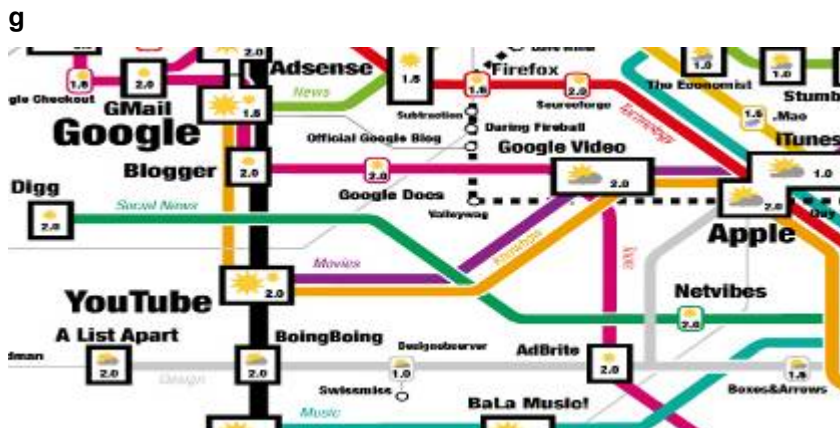
Various visualization tools have been studied. The main reason for studying these tools is to decide which visualization techniques are best suited for the requirements of presenting health records in PPHR. These tools are PC-based, which means that they may consume more memory, and mostly present better on big displays. Sample visualization results of a large chunk of data using these tools show a large visual image. The visual view might fit well on a normal sizes monitor, but will need a lot of scrolling action and key strokes in order to get to the desired location if it is on a small

display, like a mobile phone. Several examples of visualization applications and approaches used to present data will be shown in this section.

### 1.6.2.1 Trendmap 2007

Figure 1-5: Websites mind map by Trendmap 2007(<http://www.informationarchitects.jp/ia-trendmap-2007v2>, viewed 2011)

Source:<http://media.smashingmagazine.com/images/datavisualization/webtrends2007.jpg>



Trendmap is a mind map tree visualization which presents the 200 most successful websites on web arranged by category, proximity, success, popularity and perspective. Space-filling technique is used also. A sample of Trendmap is shown in Figure 1-5.

### 1.6.2.2 Newsmap

Figure 1-6: Displaying News with Newsmap (<http://www.marumushi.com/apps/newsmap/> 2011)

Source: <http://media.smashingmagazine.com/images/data-visualization/newsmap.jpg>



Newsmap shown in Figure 1-6 visually displays news headlines on-screen with different size of data blocks. It uses zoom-able and space-filling techniques. The sizes of data blocks are determined by news popularity at that moment. The popularity is defined by the number of selections by users.

### 1.6.2.3 Voyage

Figure 1-7: Voyage Presenting Feeds (<http://rssvoyage.com/> 2011)

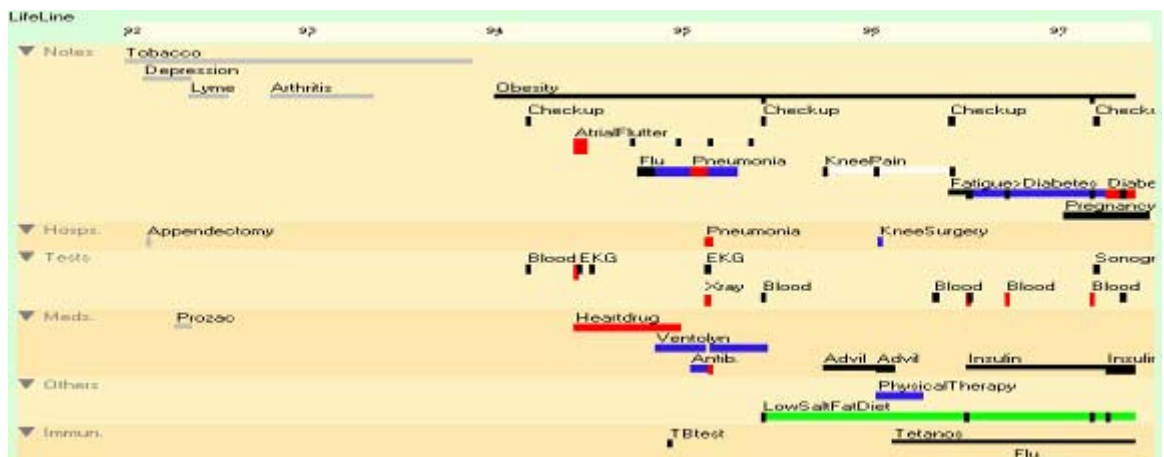
Source: <http://www.listio.com/reviews/wp-content/uploads/2008/10/voyage11.png>



Voyage is a RSS feed reader, which puts the user's feeds in layers with the newest up front, and older items diminishing in intensity as they appear to go back in space, refer Figure 1-7. News can be zoomed in and out and navigation is possible with a timeline. Zoom-able context with focus distortion techniques were used.

### 1.6.2.4 LifeLines

Figure 1-8: LifeLines Visualizing Patient Record (<http://www.cs.umd.edu/hcil/lifelines/> 2011)

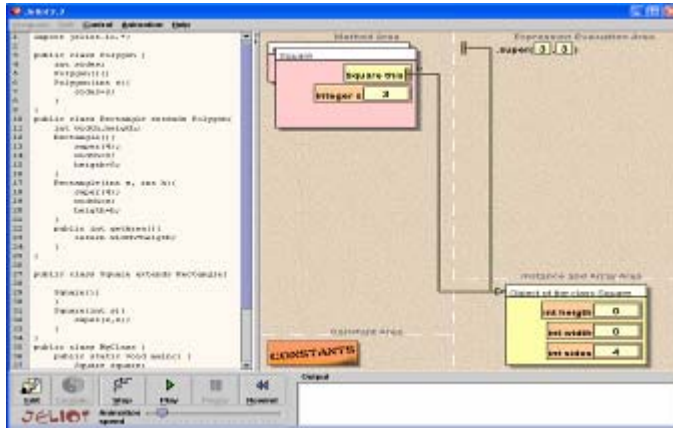


LifeLines provide a general visualization environment for clinical patient records. It is a Java application which presents a one-screen overview of a computerized patient record using timelines. In Figure 1-8, LifeLines visualization applies node-link and tree techniques and has the features including zooming, different line colour and thickness for illustrating relationships or significance. It acts as a menu and is able to give direct

access to data (Plaisant et al. 1998 <http://www.cs.umd.edu/local-cgi-bin/hcil/rr.pl?number=98-08>).

### 1.6.2.5 Jeliot 3

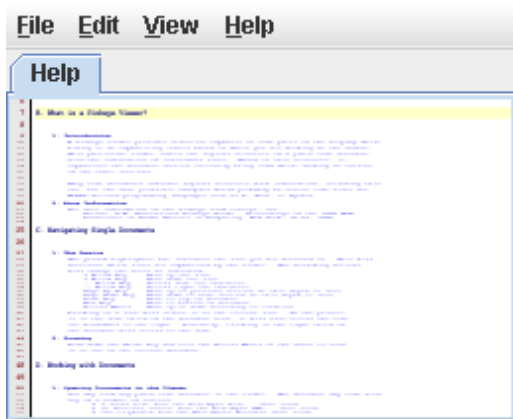
Figure 1-9: User Interface of Jeliot 3 (<http://cs.joensuu.fi/jeliot/index.php> 2011)



Jeliot 3 is a program visualization and animation tool which uses node-link and tree techniques aimed at novices who are learning programming in Java; in Figure 1-9, Jeliot 3 visualizes how a Java program is interpreted. Jeliot 3 is also used as an extension of BlueJ, which is a program development environment specifically designed to support teaching object oriented programming with the objects-first paradigm.

### 1.6.2.6 Fisheye Viewer

Figure 1-10: Fisheye Viewer Sample (<http://cgjennings.ca/toybox/fisheye/index.html> 2011)

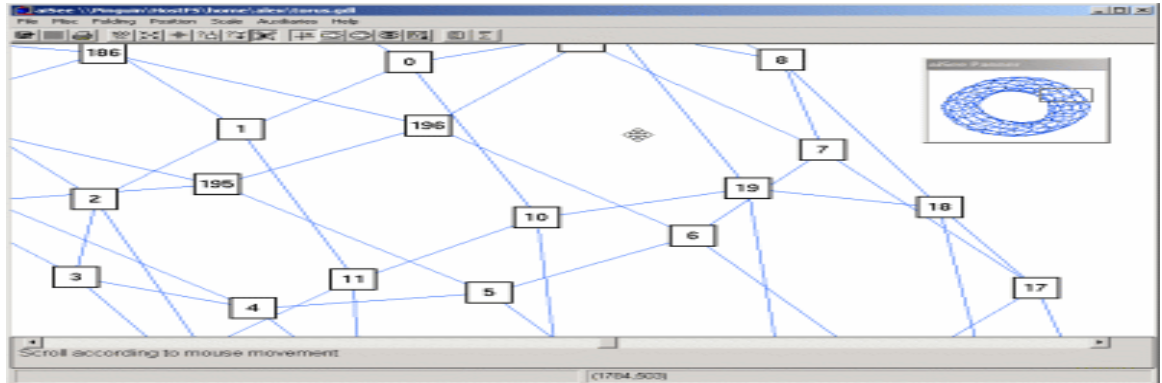


Fisheye Viewer is a Java application which applies a fisheye view which is a zoom-able technique to the display of plain text documents that are structured by the indentation of their lines. Fisheye Viewer in Figure 1-10 shows one whole piece of information on the screen without including or excluding lines based on their current degree of interest. The viewer uses scaling to scale the text vertically; text will be scaled down as the

degree of interest decreases. The characters retain the same width so that all the text lines up in the correct columns.

### 1.6.2.7 aiSee

Figure 1-11: aiSee Panel Window, explore huge graph (<http://www.aisee.com/> 2011)

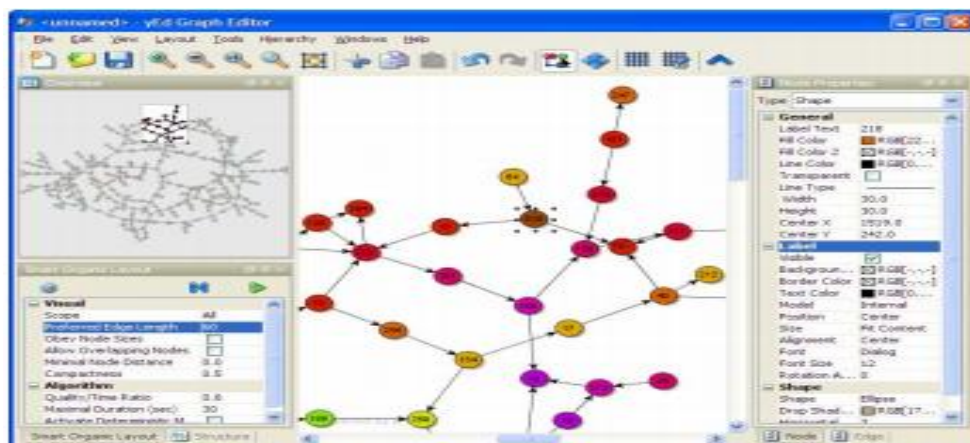


aiSee is software using zoom-able, node-link and tree techniques; it visualizes huge graphs, recursive graph nesting, and supports easy printing and export of graphs to various formats. aiSee reads texture graph specification to calculate a customizable graph layout then display it. The graph layout is displayed via a range of customisation options and can be explored interactively. It uses GDL (Graph Description Language) as the input format. Figure 1-11 is a sample screenshot of aiSee.

### 1.6.2.8 yED Graph Editor

Figure 1-12: Screenshot of yED (<http://www.yworks.com/> 2011)

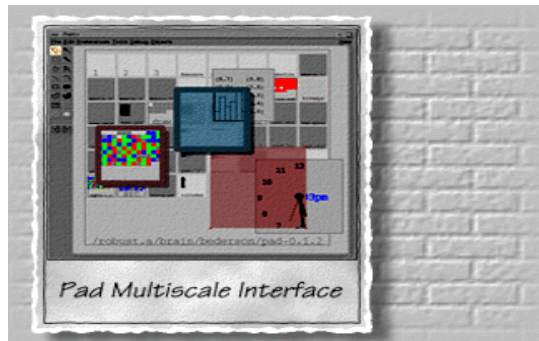
Source: [http://www.leeds.ac.uk/evie/workpackages/wp5/docviz\\_litreview\\_v3.pdf](http://www.leeds.ac.uk/evie/workpackages/wp5/docviz_litreview_v3.pdf)



yED Graph Editor as shown in Figure 1-12 is a diagram editor that can be used to generate drawings of diagrams and to apply automatic layouts to a range of different diagrams and networks. The input formats of yED are either Excel spreadsheet (.xls) or Extended Mark-up Language (XML). The few important supported diagrams are flowcharts, family trees, semantic and social networks, UML class diagrams and others.

### 1.6.2.9 Pad++

**Figure 1-13: Pad++ - Zoomable User Interfaces (ZUIs)** (<http://www.cs.umd.edu/hcil/pad++/> 2011)

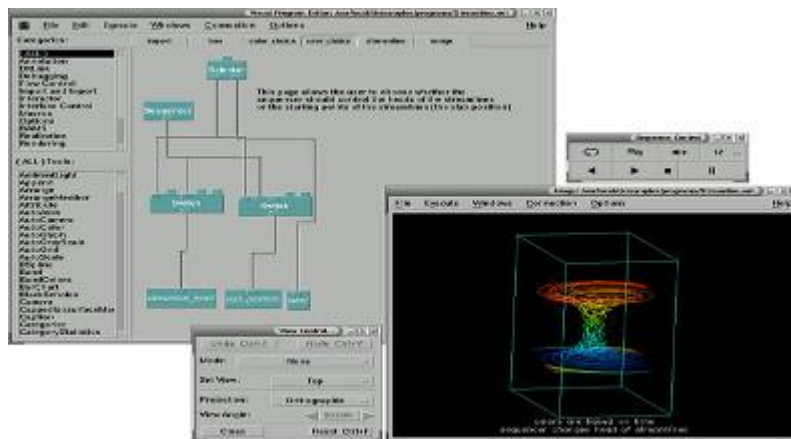


Pad++ is a graphics widget focusing in zoom-able user interface where zooming is a fundamental part of the user's interaction with the computer. Figure 1-13 shows Pad++ presenting a document to the user in the form of thumbnails in elliptical manner, which means that it is only practical for a relatively small numbers of pages. In order to achieve pleasing layouts for documents of different lengths, it requires manual change of parameters and the user has to click on the thumbnail he wishes to view.

### 1.6.2.10 Open Data Explorer

**Figure 1-14: OpenDX - Visual Program Editor and interactors (OpenDX)** (<http://www.opendx.org/> 2011)

Source: <http://upload.wikimedia.org/wikipedia/en/2/2c/OpenDx-screenshot.jpg>



OpenDX is an open source project based on IBM's visualization data explorer. OpenDX is mainly for visualizing scientific, engineering and analytical data. It consists of a graphical program editor that allows the user to create a visualization using a point and click interface. OpenDX user interface has a wide variety of interactors, direct and indirect. A sample screenshot of openDX is shown in Figure 1-14. Techniques used to visualize include zoom-able, node-link and tree. Direct interactors allow users to

manipulate images via rotate and zoom; indirect interactors like dials, switches, buttons and sliders, allow users to control various aspects of visualization (<http://www.opendx.org/about.html>, viewed 2011).

### 1.6.3 Visualization Applications Specialized for Small Displays

#### 1.6.3.1 Roambi

Figure 1-15: Roambi Sales Analytics 2010 on iPad



Roambi (<http://www.roambi.com/> 2011) in Figure 1-15 runs on any Apple mobile device that can run the Apple iPhone operating system, such as iPhones, iPads and iPod Touches. It is a mobile business application that transforms company reports and data into visualization. The figure above shows a sample report. Roambi allows user to touch, turn, analyse and share company latest information. Roambi works by connecting directly to existing business intelligence systems, reports and spread sheets, and automatically transforms them into visual mobile analytics on any iPad or iPhone. Techniques used for this visualization are node-link and tree.



### 1.6.3.2 ComponentArt Data Visualization for .NET

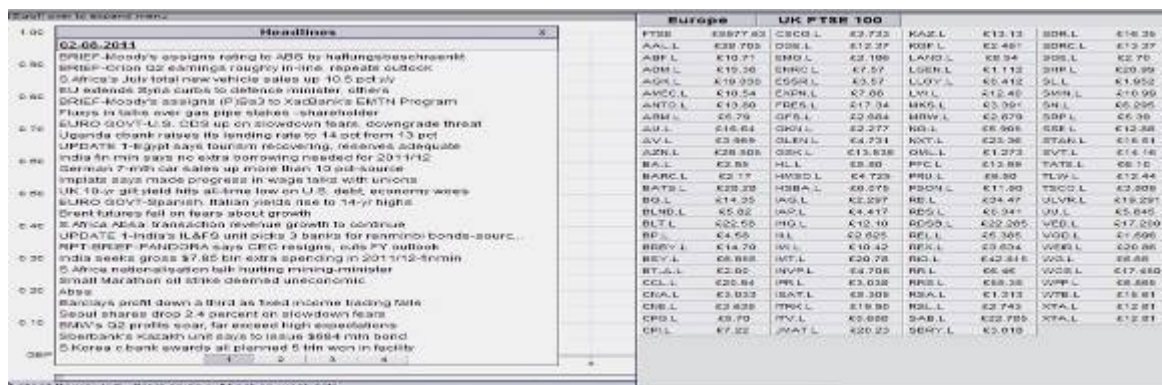
Figure 1-16: ComponentArt Data Visualization on Windows Phone 7



Figure 1-16 shows various visualizations done by ComponentArt Data Visualization package on Windows phone 7. ComponentArt Data Visualization package (<http://www.componentart.com/products/dv/> 2011) includes Charting, Gauges, Maps, Data Grids, Time Navigator and Calc Engine, which means that it uses the node-link and tree technique. It is available on computers with big display size and Windows Phone 7 on small screen display, as shown in the figure above. Support for Windows Phone 7 is integrated into the main Data Visualization for Silverlight package. Various themes and colour palettes are provided to define the visual characteristic of the interface. The Data Visualization suite is designed to handle extremely large amounts of data such as millions of records.

### 1.6.3.3 iGrapher

Figure 1-17: iGrapher Main Page



iGrapher (<http://igrapher.com/> 2011) is a free web-based financial market visualization tool for charting, analysis and prediction of different stock, currency and commodity markets. It applies zoom-able technique for the news heading, and node-link and tree

for the stocks analysis. Since it is a web-based application, it can be accessed by devices like iPhones or iPads as shown in Figure 1-17.

Figure 1-7: Voyage Presenting Feeds (<http://rssvoyage.com/> 2011) is a screenshot of the main page of iGrapher, it consists of news activity of a stock on the left side of the screen and market data on the right. The news is listed by headings only; a scrolling bar is not available, and news is divided into pages. Users can select to plot different international stocks from the markets against different commodities such as gold or currencies, as indicated in the following figure.

**Figure 1-18: Markets Plots on iPhone**

Source: <http://www.apple.com/webapps/productivity/igrapher.html>



#### 1.6.4 Limitations of Visualization Tools

Most of the tools are designed for scientific and business data visualization. The availability of text or document visualization tools is much more limited, and the available ones are not suited for small displays like those found on mobile phones. The text tools do not offer much information content to the user, and also offer few features to navigate or explore the information. Visualization tools are not common on older phones too; the tools that have been studied here are only available to smart phone systems such as iPhones, iPads, and Windows phone.

#### 1.7 Constraints on EHRs - Standards

As the drive for compatibility increases, the roles of standards should also increase. Historically, health information systems have evolved in a multitude of little places to solve specific little problems. In the 1980s the idea arose that this many systems

should be able to communicate with one another in some way, so that they could share data. Many standards arose much in the same way languages arose among human beings for communication.

### **1.7.1 Standards for EHR Content and Structure**

#### ***1.7.1.1 ISO18308***

The ISO18308 (ISO/TS 18308 2004) is also known as Requirements for an Electronic Health Record Reference Architecture. It is not a functional requirement for an EHR system but rather a set of clinical and technical requirements for a record architecture that supports using, sharing, and exchanging electronic health records across different health sectors, different countries, and different models of healthcare delivery (openEHR 2007).

The development of ISO 18308 was undertaken in three separate stages.

The first stage involved an extensive literature search and direct contact with domain experts in many countries to identify as many existing sources of EHR requirements as possible. Stage 2 of the project involved collation of the more than 700 requirements identified in the first stage and the development of a suitable hierarchical framework of headings under which the requirements could be organized (openEHR 2007). The final stage of the project was the development of a consolidated set of EHR requirements from the 590 source requirements which remained at the end of stage 2 (openEHR 2007).

#### ***1.7.1.2 ASTM e1384***

According to the ASTM E1384 Standard Guide for Content and Structure of the Electronic Health Record (ASTM 2006) the EHR serves all of the functions of a traditional health record with many advantages. Some of these advantages include:

- A unified repository of healthcare information
- Information that is accessible from multiple sites
- More efficient communication between healthcare providers
- Cross-patient retrievals will provide statistics needed by clinical, outcomes, and health service researchers as well as administrators and managers
- Better defined policies and procedures to improve healthcare practice
- A longitudinal health record that can be developed more efficiently and effectively

However, as advantageous as it may be to develop an electronic health record, certain standards on the content of the health record are necessary in order to meet this goal

### **1.7.1.3 HL7 CDA**

The HL7 Clinical Document Architecture is an XML-based document mark-up standard that specifies the structure and semantics of clinical documents for the purpose of exchange (AAFP 2005). CDA documents derive their meaning from the HL7 Reference Information Model (RIM) and use the HL7 Version 3 Data Types; The CDA specification is richly expressive and flexible document-level, section-level and entry-level templates can be used to constrain the generic CDA specification (Lubinski and Ruggeri 2005). A CDA document is a defined and complete information object that can include text, images, sounds, and other multimedia content. The HL7 CDA clinical document contains observations and services, and has the following characteristics (Alschuler 2006; Reider n.d.; Kibbe 2007):

- *Persistence*: continues to exist in an unaltered state, for a time period defined by local and regulatory requirements
- *Stewardship*: maintained by an organization entrusted with its care
- *Potential for authentication*: constitutes an assemblage of information that is intended to be legally authenticated
- *Context*: establishes the default context for its contents
- *Wholeness*: authentication of a clinical document applies to the whole and does not apply to portions of the document without the full context of the document
- *Human readability*: human readable, guarantees that a receiver of a CDA document can algorithmically display the clinical content of the note on a standard Web browser.

### **1.7.1.4 openEHR**

The openEHR is a set of open specifications for an electronic health record architecture which allows any compatible application, organization or provider to share access to standardized data (openEHR 2007). It is developed to improve semantic interoperability among health records. openEHR ensures that the underlying health data is accurate, simpler to capture, store, aggregate, query and exchange safely. All clinical knowledge concepts which are captured in a structured way known as archetypes are designed as maximal data sets for the universal use-case so the same data definitions can be used in any software application (openEHR 2007).

## 1.7.2 Standards for Communications

### 1.7.2.1 HL7

HL7 and its members provide a framework for the integration of electronic health information. V2.x of the standards, which support clinical practice and the management, delivery, and evaluation of health services, are the most commonly used in the world (Lubinski and Ruggeri 2005). "Level Seven" refers to the seventh level of the International Organization for Standardization (ISO) seven-layer communications model for Open Systems Interconnection (OSI) - the application level (Alschuler 2006). The application level interfaces directly to and performs common application services for the application processes. Although other protocols have largely superseded it, the OSI model remains valuable as a place to begin the study of network architecture.

### 1.7.2.2 CCR (Continuity of Care Record)

The Continuity of Care Record is an ANSI-accredited health information technology standard. It has been developed and is maintained by volunteers from both health care and technology professions, under the auspices of ASTM International, the world's largest standards development organization (SDO) (AAFP 2005). The CCR standard's purpose is to make it possible for a digital summary of relevant administrative and clinical health information about an individual to be created, stored, and passed from one computer system to another with little or no use of human resources necessary in the exchange (Kibbe 2007; Alschuler 2006). The ability of different computer systems to read and interpret each other's sets of data is known as *interoperability* (Kibbe 2007).

The CCR standard was developed to address the problem of the pervasive *lack* of interoperability among health care computer software, such as electronic health record systems used by doctors, hospitals, health plans and other health care entities. CCR is envisioned as a way benefit patients and consumers as the basis of a digital personal health record, PHR, and for making such a PHR *portable* (Reider *n.d.*).

### 1.7.2.3 CCR VS CDA/CRS

The CDA was designed to support incremental semantic operability. As defined by the HL7 Structured Documents Technical Committee, What this means is that there is a range of complexity allowed within the specification and users must set their own level of compliance. (AAFP 2005) In addition, the CDA and CRS explicitly allow local extensions and configurability.

The CCR was designed to require and enforce explicit semantic interoperability. The EHR and PEHR vendors have demanded that there were universal compliance with a defined syntax, semantic content, and explicit structure to all CCRs and that no local extensions or configurability be allowed (Alschuler 2006). The vendors as well as the clinical providers have defined the level of completeness and specificity to enforce this.

#### Data Structural Architecture

The CDA and CRS are based on the HL7 Reference Information Model (RIM). The RIM is a data model that defines health care data objects using an OMG (Object Management Group) Entity-Relation (ER) model (Alschuler 2006). The RIM is the basis for all emerging HL7 standards. The RIM is a conceptual model and not a production database model. The CDA and CRS are intended as expressions of intact documents and are not explicitly designed for filtering and providing views onto data (AAFP 2005).

The CCR is based on an XML-based object-relational data model that represents complex health care data as highly constrained and highly specific data objects (Reider n.d.). The CCR object-relational data model is a production database model designed for EHRs, PHRs and data repositories. The CCR is built from discrete data objects so that those data objects can be filtered, viewed, and organized without changing the information content or integrity while at the same time facilitating reuse of selected portions of the data for disparate decision processes (AAFP 2005; Alschuler 2006).

Starting around 2005, HL7 and ASTM harmonized the CDA and CCR (AAFP 2005) (Lubinski and Ruggeri 2005). The outcome is known as the Continuity of Care Document (CCD) and makes CCR data objects and specificity fully able to be expressed in the CDA. Out of this work a set of XSLTs (XML transforms) were created that will support the seamless transformation of data from HL7 CDA (XML) syntax to CCR (XML) syntax (Lubinski and Ruggeri 2005; Alschuler 2006). The intent is for these transforms (XSLTs) to allow transformation with no data loss.

#### **1.7.2.4 XML**

The CDA and CRS use an XML syntax modelled and are defined for Version 3.x HL7 messaging (Lubinski and Ruggeri 2005). The CDA and CRS store human readable formatting information in the XML document. In addition, the narrative data in the CDA and CRS is not required to match the structured data. The CCR uses an XML syntax based on W3C-compliant rules used within the general computer industry and is intentionally non-health care specific to optimize the use of general computer industry

XML tools and skill sets (Reider n.d.; AAFP 2005). In contrast to the HL7 CDA and CRS, the ASTM CCR explicitly prohibits the use of XML tag attributes to contain data all data in the CCR must be tagged. All of the XML and tags within the CCR are human as well as machine-readable and the CCR stores human readable text as text strings or structured data. Narrative in the CCR is absolutely required to exactly and explicitly match its structured representation so that human readable and machine-readable data are always identical and synchronized (AAFP 2005).

### **1.7.3 Coding Systems**

Each year, avoidable deaths and injuries occur because of poor communication between healthcare practitioners. The delivery of a standard clinical language for use across the world's health information systems can therefore be a significant step towards improving the quality and safety of healthcare. Coding systems aim to improve patient care through the development of systems to accurately record health care encounters. Vocabularies are not standards as such, but they contain standard words for health concepts, thus helping to standardize health records which use them. Ultimately, patients will benefit from the use of coding systems, for building and facilitating communication and interoperability in electronic health data exchange.

#### ***1.7.3.1 ICD-CM***

The International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) is based on the World Health Organization's Ninth Revision, International Classification of Diseases (ICD-9). ICD-9-CM is the official system of assigning codes to diagnoses and procedures associated with hospital utilization in the United States (NHS Connecting 2007). The ICD-9 is used to code and classify mortality data from death certificates.

The ICD-9-CM consists of (NHS Connecting 2007):

- A tabular list containing a numerical list of the disease code numbers in tabular form;
- An alphabetical index to the disease entries;
- Classification system for surgical, diagnostic, and therapeutic procedures in alphabetic index and tabular list.

The National Centre for Health Statistics (NCHS) and the Centre for Medicare and Medicaid Services are the U.S. governmental agencies responsible for overseeing all changes and modifications to the ICD-9-CM (Oakes 2006).

Countries such as Australia and Malaysia use ICD-10.

### ***1.7.3.2 SNOMED-CT (Systematic Nomenclature of Medicine - Clinical Terms)***

SNOMED-CT is a terminology used by physicians, health professionals and veterinarians to optimize for computer storage and retrieval from clinical information systems. It is a controlled vocabulary with comprehensive coverage of diseases, clinical findings, therapies, procedures and outcomes. Clinicians and organizations use different clinical terms that mean the same thing. For example, the terms heart attack, myocardial infarction, and MI may mean the same thing to a cardiologist, but, to a computer, they are all different. There is a need to exchange clinical information consistently between different health care providers, care settings, researchers and others (semantic interoperability), and because medical information is recorded differently from place to place, a comprehensive, unified medical terminology system is needed as part of the information infrastructure.

SNOMED is not about the codes, but the terms, it is unlikely clinicians will see the codes. SNOMED-CT represents distinct clinical meanings; associated with each concept is a set of relationships and a set of names or terms (NHS Connecting 2007). There are currently (2010) around 400,000 terms in SNOMED-CT, it is identified by a unique numeric identifier that never changes and a unique human readable name, and it has differing levels of granularity (Oakes 2006). SNOMED-CT concepts can be primitive and are often referred to by an information model such as HL7, beside that SNOMED-CT can also enables more complex description to be used.

### ***1.7.3.3 LOINC (Logical Observation Identifiers Names and Codes)***

LOINC was initiated in 1994 as a response to the demand for electronic movement of clinical data from laboratories that produce the data to hospitals, physician's offices, and payers who use the data for clinical care and management purposes (LOINC 2010).

The purpose of the LOINC database is to facilitate the exchange and pooling of results for clinical care, outcomes management, and research. Currently, most laboratories and clinical services use HL7 to send their results electronically from their reporting systems to their care systems. However, the tests in these messages are identified by means of their internal, idiosyncratic code values. Thus, the care system cannot fully "understand" and properly file the results they receive unless they either adopt the producer's laboratory codes, or invest in the work to map each result producer's code system to their internal code system. LOINC codes are universal identifiers for laboratory and other clinical observations that solve this problem.



The scope of the LOINC effort includes laboratory and other clinical observations. The laboratory portion of the LOINC database contains the usual categories of chemistry, haematology, serology, microbiology (including parasitology and virology), toxicology; as well as categories for drugs and the cell counts, antibiotic susceptibilities, and more (LOINC 2010). The clinical portion of the LOINC database includes entries for vital signs, hemodynamic, intake/output, EKG, obstetric ultrasound, cardiac echo, urologic imaging, gastro endoscopic procedures, pulmonary ventilator management, selected survey instruments (e.g. Glasgow Coma Score, PHQ-9 depression scale, CMS-required patient assessment instruments), and other clinical observations (LOINC 2010).

#### ***1.7.3.4ICPC 2e***

The International Classification of Primary Care (ICPC) is a coding system developed to order medical concepts into classes that have been chosen on the basis of their relevance for primary health care. It is a biaxial system based on chapters and components and has been constructed on the principles of symptoms, complaints, and reasons for encounter, interventions, diseases and diagnoses. ICPC provides a coding system that can be mapped to ICD-10, and allows frontline health providers to organize the process of those interventions in the primary care setting. It has a reason for encounter approach and is based on the episode of care longitudinal patient-oriented data model (Verbeke et al. 2006). The ICPC classification system gives solution to the lack of quality data available in primary health care settings in Canada, and provides an opportunity to examine clinical epidemiology and clinical decision making in a real-world primary care context (Centre of Health Information 2006).

#### ***1.7.3.5Comparisons***

According to researchers who did a comparison on LOINC, SNOMED-CT and ICD-CM (Chang et al. 2005), the overall degree of coverage of patient safety terms and concepts provided by the vocabularies was reported by tabulating the frequency of each Likert item assigned to the 160 concepts.

POPULATION STUDIED (Chang et al. 2005): All patients and providers affected by adverse events in health care.

PRINCIPAL FINDINGS: LOINC had the most complete coverage of the concepts present in PSET (Likert 1 & 2) (ICD-CM 63%; LOINC 72%; SNOMED-CT 65%), but a combinatorial vocabulary provided the most comprehensive coverage (ICD-

CM/LOINC/SNOMED-CT 93%). LOINC covered 59% (95) and SNOMED-CT covered 58% (92) of single and compositional concepts completely (Likert 1 only). Coverage was best for concepts found in the Domain and Type classifications, describing health delivery settings, provider and patient characteristics, and patient management factors. Missing concepts were largely related to the assessment of harm, clinical performance, and human errors. SNOMED-CT had 9% (15) and LOINC had only 2% (3) unmatched concepts and terms, whereas ICD-CM had 26% (41). Individually, ICD-10 had slightly better coverage than ICD-9 (ICD-10, 59%; ICD-9 57%). CONCLUSION: Results suggest that no single medical vocabulary can sufficiently represent the patient safety domain completely. The overall coverage of the concepts in patient safety was good. LOINC and SNOMED-CT have a compositional nature and a richer taxonomy to construct post-coordinated patient safety codes.

## **1.8 Proposed Portable Personal Health Record (PPHR)**

Accessibility and availability are major issues for health records in Malaysia and elsewhere. Most EHR systems are in hospitals or private clinics, so patient information is not available or accessible outside. PHR systems like Google Health and Microsoft Health Vault are Web-based and based in USA. They are only accessible where there is Internet access, which excludes large sections of Borneo (and other areas). Input from health institutions outside of North America is not possible. M-Health systems are in the hands of healthcare professionals, so the patient information they collect is not always available wherever the patient is. They also often require broadband access, which further restricts their accessibility. Vietnam and parts of Malaysia have created paper-based PPHRs in the forms of booklets which are carried by the patients, and so are accessible and available.

Among these systems, there is no obvious sign of interest in visualizing health records. The ability to navigate a health record efficiently is vital, especially for a small display handheld device like mobile phones. Not only should the patients themselves be able to navigate health data easily, but medical officers should also be able to access specific health information fast enough for any emergency matter.

We have developed a digital version of these PPHRs. It can be carried by individuals in their mobile phones, so that it is accessible and available. According to the Ninth Malaysian Plan, continuity of care is a challenge in healthcare in Malaysia. One of the main purposes of the IT infrastructure in healthcare is to support continuity of care by

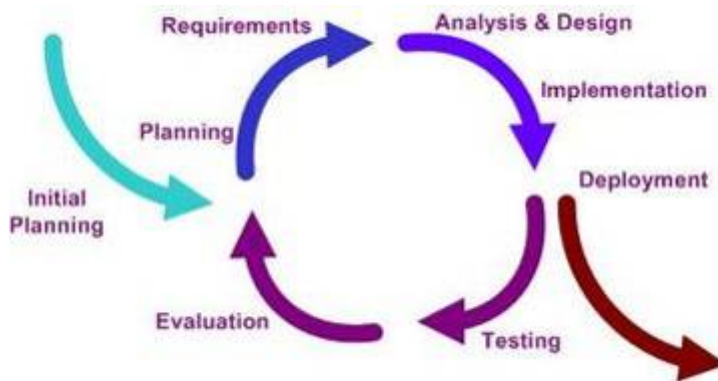
making patient information available when and where it is needed. However, as mentioned above, the IT infrastructure in Malaysian healthcare is still deficient. Very few government hospitals have complete hospital information systems. Few private practices are computerized. There are no concrete plans or timetables to rectify this situation in the near future. Probably the fastest and most cost-effective way to introduce electronic health records at a national level would be the installation of a Personal Health Record (PHR) system such as Google Health or Microsoft Health Vault. However, access to such systems is through the Web and many parts of Malaysia, especially East Malaysia, still does not have or only has very limited Web access. On the other hand, the use of cellphones has proliferated throughout Malaysia, even to areas with no Internet access. GSM cellphone networks now have the widest coverage of any communications network in rural areas. Here we describe a project which makes use of cellphone technology to implement PHRs. It is a cellphone application called a Portable Personal Health Record or PPHR. By using this technology we extend the reach of PHR systems beyond the Web to include the entire GSM cellphone network. More specifically, this dissertation concerns the design and implementation of a graphical user interface (GUI) for a PPHR.

## Methods

### 2.1 Development Methodology

An iterative development is used to develop this project, as shown in Figure 2-1.

**Figure 2-1 Iterative Development Model (Software Testing Concept 2012)**



Ability to backtrack is the main reason the iterative model is chosen to develop PPHR. At each iteration process, design modifications are made and new functional capabilities are added. The iteration involves the redesign and implementation of tasks, and the analysis of the current version of the system.

### 2.2 Planning of PPHR

#### 2.2.1 Source of Information

The research is based on literature studies where research results are published as journal papers, conference papers and books were reviewed. According to the literature, HIS is one of the major concerns of the Malaysian Government in the Ninth Malaysia Plan and most hospitals in Malaysia are still using paper-based documents for processing information. Standards and coding systems are also reviewed, from literature studies and from training session of middleware at SAINS introduced by Dr. H. Lee Seldon.

During the first few weeks of research, not much updated information on Malaysian Healthcare could be found from books, journals or online articles. In order to obtain more accurate information, interviews with healthcare professionals were conducted.

The latest information was obtained, and was used to support what was stated in the literature studies. Interview questions were prepared and reviewed.

### *2.2.1.1 Interviews on Current Health Systems and Records in Malaysia*

The interview was conducted to find out the following:

- Groups/Types of users in health care Malaysia
- Different wards
  - General
  - Internal medicine
  - General surgery
  - Obstetrics
  - Podiatry
  - Cardiology
  - Others?
- How many and which hospitals are using Health Information System?
  - System name
  - Issues and limitations
  - Does it handle health records?
  - Does it communicate with other healthcare providers?
- How is current health records handled?
  - Form and format
  - How and where to store and access records
  - Who is involved in handling health records
  - How relevant staff share/use patients health records
  - Ownership of health records
  - Patients access to own records
  - Individual right protection for health records
  - Systems used to handle health records
  - Major problem handling health records
- Is PHR systems available in Malaysia?
  - Electronic or paper-based
  - Name of systems use to handle PHR
  - Ways to accessed
  - Individual right protection for health records
- How does communication work between Malaysia s rural areas and town areas?
  - Communication medium in rural areas.

- Healthcare providers communications
  - Inside hospitals
    - Is there a particular procedure?
    - Phone, paper, email or others?
    - How were orders placed? Electronic, paper-based, or phone?
    - Process lab report electronically?
  - Outside hospitals
    - Is there a particular procedure?
    - Referrals by letter, phone, email or others?
    - Does hospital receive referrals by letter(brought by patients), phone, e-mail or others?
- Funding
  - Government, partially government, insurance, private?
  - How does government, insurance, etc. communicate with hospitals?
- IT
  - Do all hospitals have computers? If yes, what kind (PC?), platform?
  - Internet availability
  - Familiarity of healthcare users to computer?
  - Hospital network availability
  - Electronic Health Record availability, problem with current HER
  - Communication standards and coding systems

Mr. Ngui How Chen, who was State Medical Assistant Head of Sarawak Healthcare Department (Ketua Penolong Pegawai Perubatan Negeri, Jabatan Kesihatan Negeri Sarawak), and Madam Goh Teck Wang, who is a very experienced nursing sister who worked at several government and private hospitals in rural and non-rural areas for almost 40 years were interviewed. According to Mr. Ngui, there are current solutions available to handle data sharing of PEHR such as internet, GSM or satellites. However, there are only a few hospitals using HIS (cf. Result). The approach chosen for this project is mainly based on GSM and a prototype of PPOEHR done by Seo Wei Jye (Seo 2009). Knowledge for PPOEHR was obtained from Seo Wei Jye during a weekly Friday meeting throughout the months from August to December 2010, ideas were shared and features of PPOEHR were introduced.

The interviews were mainly focused on how health records are handled. How many hospital or clinics private or non-private did Mr. Ngui and Madam Goh know actually

used HIS? Effectiveness for the current health record system, is it time consuming, secure, accurate, accessible and available for both healthcare provider and patients? Mr. Ngui s was able to answer general questions based on his previous position and experience. Madam Goh Teck Wang focused on health record handling, how patients obtain their health record in specialized cases, and the summary of specialized case health records written by the doctor/specialist. Information provided by Madam Goh is convincing because of her experience. According to Madam Goh Teck Wang, only the Sibü General Hospital used TPC. Madam Goh says all the medical records are in paper-based, even in the Sibü General Hospital. The information obtained from interviews concurs with the literature studies.

Apart from literature studies and interviews, training sessions were attended for an open source HIS named myCare2X (Healthcare Consulting GMBH 2007), MIRTH and OpenEAI. These training sessions provided ideas on how these systems works. My final application shall be able to maintain patients health information according to health elements that will be designed to fulfil matching between ICPC-2 which is used by the PEHR, CCR which is used by Google Health and HL7 which is used by myCare2X. Data transportation will be done through GSM communication. SMS, SMS Gateway.

### **2.2.2 GSM Communication**

GSM is the most popular standard for mobile phones. Currently GSM has the most coverage around the world (GSM Association 2007). Coverage of GSM is shown in Figure 2-2, plotted in purple colour. The current plan is to use PEHR with GSM connections as it could be very useful for users in rural areas who mostly do not have internet services or even a phone line.

**Figure 2-2 Malaysia GSM coverage**

Source: (GSM World 2009)



### 2.2.3 Use of a Prototype – The Portable Problem-Oriented Electronic Health Record (PPOEHR)

The PPOEHR prototype developed by Seo Wei Jye (Seo 2009), supervised by Dr. H. Lee Seldon, will be a reference for my system. The proposed system partially follows the way the PPOEHR operates. The prototype is stand-alone and it stores health information on a mobile device. The current proposal is to revise the PPOEHR to utilize cellphone technology. PPOEHR is planned to have few important requirements (Seldon and Moghaddasi 2007): problem oriented, portable, identification of owner and compatible with standards. Besides that, the health information in the system should be as short as possible, while the information density must be as high as possible, and it must be legible to people. My proposed system will try to fulfil the requirements as much as possible.

Google has implemented Google Health (Google Health 2009) to provide a free, Web-based Personal Electronic Health Record System. This represents a solution for a PEHR via Internet, but access to it both for viewing and for data entry must be through the Web. My system will focus on handling PEHR through GSM, since the GSM network covers areas which do not have Internet connectivity. In a separate project the CCR will be chosen as the standard message format for communications between the



PPHR Google Health (and the hospital information system myCare2X (Healthcare Consulting GMBH 2007)) for a few reasons: simple, structured the way healthcare providers think, easy to generalize since it is a direct XML implementation, and it is also adopted by Google Health. Although the CCD might be better than the CCR in some cases, the CCR is simpler and is more than enough for this system. The ICPC-2e vocabulary will be used in this system as it is specialized for primary care, and it is in a simple form. As for the comparison between MIRTH and OpenEAI as a communications gateway of the PPHR system, as mentioned earlier MIRTH is more than adequate to satisfy requirements for the PPHR. Thus, communications between the mobile PPHR and a web-based PHR such as Google Health can go via SMS gateway (GSM network) and Mirth (for HL7 and CCR message formats). Note that since this system was conceived Google has announced that it is closing the Google Health project as of 1 January 2012.

## **2.2.4 Issues to Be Considered**

### ***2.2.4.1 Validity of Information***

Since it is a PHR, it means that patients are allowed to make changes to their health records and they can add in or remove information depending on their own liking. This may cause validity problems. Patient might not have enough medical knowledge to modify, or to decide their own illness which they may assume they have. The current plan for maintaining validity of the PHR is to separate formal health records from the healthcare provider and the add-in data by the patient. That way, healthcare professional can revise both and do the best analysis on patient health without any mistakes. Insurance or any other formal procedures by companies or government will not accept PHR as a formal document because of its modification ability. So it is better that the PHR is separated into a modified version and an original version. That way, it can even increase the usage of the PHR.

### ***2.2.4.2 Ethical Framework***

A suitable ethical framework will be revised. The ethical framework in mind shall consist of 2 major elements: confidentiality and data protection. Confidentiality ensures that only authorized individuals have access to the patient's information. Data protection carefully considers the content to be entered into the computer system and prevents unauthorized creation, modification or deletion of data.

#### **2.2.4.3 Usability**

Users might spend extra time learning to use the PPHR. Usability is an important issue as it directly influences the usage of the system. If the system has a low usability, it means that less people are using it, which leads to the failure of the proposed research.

#### **2.2.4.4 Quality**

Since the message of the system should be kept as short as possible while maintaining its accuracy, the type of data to be included as information should be decided carefully to ensure the quality of the health record.

### **2.2.5 System Difficulties**

Currently some of the system difficulties in implementing the system have been considered. The possible difficulties include:

- Associate old paper based documents into electronic medical records. For all these years Malaysia healthcare providers are using paper based documents, too many paper documents and also as we can see from Figure 1-1 to Figure 1-4, it will be almost impossible to be converted into electronic based.
- Extensive hand written documents might decrease the accuracy of data. There are typos, and some handwriting is hard to read. Besides that, the documents are in different languages such as Bahasa Melayu and English.
- Contents of current health records might be illegible for conversion.
- Hardware and software compatibilities.

### **2.2.6 Quality Plan**

Table 2-A: Timing, quality criteria, quality assurance methods and evidence of compliance for the PPHR quality plan.

**Table 2-A: Quality Plan**

Output			
Timing	Quality criteria	QA method(s)	Evidence of compliance
End of each phase and iteration	Fitness for purpose	Using test plan and review by the team members and supervisor	The positive feedback from reviewer and the test result is pass
End of each phase and iteration	Best practice for processing	Using test plan and reviewed by the team members, supervisor and co-supervisor	Positive outcome
As needed according to work plan component	Adhere to a school policy	Testing with real world data	The function execute successfully without violate rules set
Part of each test plan	Usability	Inviting non development team member to use the system	A user can handle the system in a short time
As needed according to work plan component	Qualify and fit to organizational strategies	Review by project supervisor and co-supervisor	Agreement on the qualification and fit

## 2.3 Requirements of PPHR

### 2.3.1 ISO 18308 Requirements for PPHR Architecture

The system requirements shall meet requirements of ISO 18308 as much as possible. The ISO 18308 includes requirements for Structure, Process, Communication, Privacy

and Security, Consumer/Cultural. The ISO 18308 requirements will be compared with the finalized system later.

See Table 9 in Section 4.2.1 for more ISO 18308 items.

### **2.3.2 Functional Requirements**

- Show list of medical elements in categories
- Add and Store Health Information
- Update Health Information

### **2.3.3 User Interface Requirements**

#### *2.3.3.1 Display, View*

The PPHR record itself contains mostly (or only) text. However, depending on the health status of the person, there may be a large amount of text.

There are different possible ways of viewing a textual health record. These include,

- Viewing all entries, this would show all entries in the order in which they were entered, although there are other possible ways of sorting entries
- A selection relating to a Problem (Problem Oriented Medical Record or POMR, Weed 1969), for purposes of diagnosing the cause of a problem, a healthcare provider would view the relevant entries; these would be those around the time of the problem's appearance, as well as ones with similar content or some other relation to the problem
- A selection by Date Range. The rationale for this would be similar to the problem-oriented view
- A selection by Keyword. Healthcare providers often follow the progress of certain parameters over time, e.g. fever in cases of infections, glucose levels for diabetes, certain enzyme levels as indicators of heart or liver functionality, etc.
- A selection based on a Combination of the above

Of course the entries can also be viewed differently:

- As lists of text
- In some cases as graphs or charts
- Potentially even as graphical interpretations

#### *2.3.3.2 Input*

There are different ways to enter (textual) data into a PPHR. As the record is textual, one mode of input would be with text. For textual input there is also more than one

possibility, the user could enter free text, i.e. type. This was the mode used by the PPOEHR (Seo, 2009), the ancestor of the PPHR, the user could select items from lists (of text).

Images and diagrams can also be used in place of textual descriptions. This could be appropriate for inputting:

- Anatomical locations, i.e. where it hurts
- Chartable items, e.g. temperature, height, weight, glucose levels, etc.

Furthermore, the capability of smart phones to interact with many types of external devices via Bluetooth or USB connections allows direct input from many types of sensors such as thermometers, blood pressure devices, etc. For the PPHR graphic mode, users must indicate the body part or anatomical region of health problems (and procedures and diagnoses), including, however, overall, mental and other not anatomically located problems; only additional user data will be text input.

### ***2.3.3.3 Usability Requirements***

- The system shall be user friendly.
- The system shall provide error messages.
- The system shall allow users to navigate freely.
- The system shall provide help instructions.
- The system shall indicate the user's current location.
- Simple and understandable terms shall be used in this system.

## **2.3.4 Organizational Requirements**

### ***2.3.4.1 Delivery Requirements***

By 29 February 2012

### ***2.3.4.2 Implementation Requirements***

Application must run on different brands and models of portable devices, especially mobile phones which support Java 2 Platform, Micro Edition (J2ME).

## **2.4 Analysis and Design of PPHR**

Given the requirements described above, one realizes that there are many possible configurations of a PPHR. To mention a few,

A PPHR could purely text-based.

The input, storage and display would all be text.

Text-based with GUI.

The data storage would be text, but both input and display could involve graphics.

As a recording station with input from the user and from sensors or other external sources (e.g. SMS).

A full-fledged medical system including not only collected data but also knowledge management to continually monitor the data, i.e. the person's health status.

## **2.4.1 User Interface (UI)**

### ***2.4.1.1 Problem: Language***

Although English may be the primary international language used in health care, many users will not be familiar with it, especially medical terminology.

#### ***2.4.1.1.1 Solution: Translations***

List of elements shall be available in various languages. User may choose to use the PPHR in specific language provided.

### ***2.4.1.2 Problem: Entering Data via Text (typing)***

Seo (2009) tested a purely text-based prototype, the PPOEHR or Portable Problem-Oriented EHR, with 10 participants from Kuching. Most of the participants are literate in English, Chinese and Bahasa Melayu, but that is just from 10 participants. Malaysia is a multi-cultural country. The Chinese language is an optional subject available from primary school; many people do not understand Chinese.

The main problem with the PPOEHR was that users had to type in each data entry by themselves. The comments of most participants were that it is too difficult to use and navigating through the whole system consumed a lot of time. In response to this, it was decided to use lists of choices for much of the user input.

#### ***2.4.1.2.1 Solution: Use of Lists***

The plan was the user shall be able to select choices from lists of entry types, complaints/problems, anatomical locations for complaints, test results, diagnoses, etc. This is to reduce the need for users to input text.

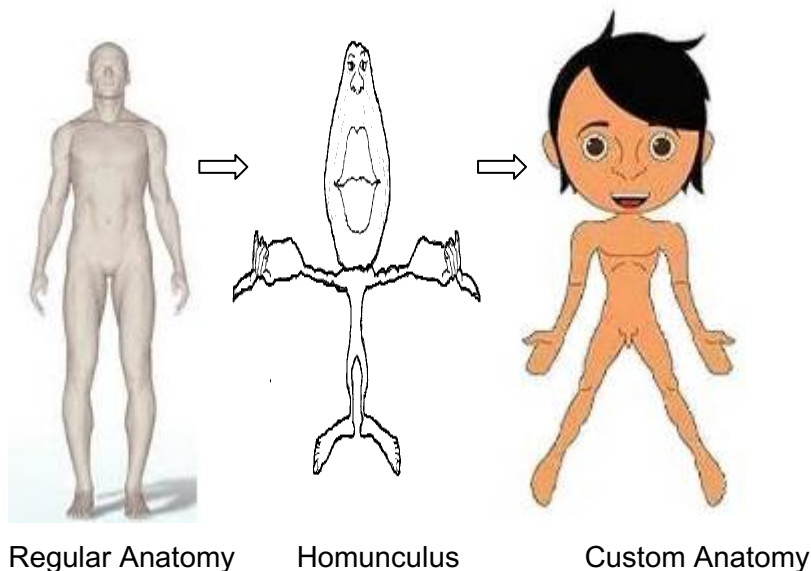
#### ***2.4.1.2.2 Solution: Use of Graphics***

Images can be used to represent body parts, as a picture is worth a thousand words. Pointing and clicking on an image should be faster and more intuitive than typing text or even selecting from multiple lists.

A single body diagram can give the locations of many different regions. In order to have every part of human body to be selected from an anatomical diagram in a limited screen size phone is difficult. For instance, head has at least 5 parts, ears, eyes, noses, mouths and the head itself. On the other hand, external body has chests, abdomen and sex organs. A regular anatomical diagram would have the body size much larger than the head, and yet there are more parts to be selected from head than body.

Homunculus is commonly used to describe the distorted scale model of a human drawn to reflect the relative space human body parts occupy on the sensory cortex and the motor cortex. The lips, hands, feet, and sex organs have more sensory neurons than other parts of the body, so the homunculus has correspondingly large lips, hands, feet and genitals. Use of homunculus is efficient for body part selections but the different size of every body part might cause uncomfortable view for viewers. A custom anatomical diagram with the idea of homunculus is created. Comparison between regular anatomical diagram, homunculus and custom created diagram are shown in Figure 2-3.

Figure 2-3: Anatomy Design



#### ***2.4.1.3 Problem: Entering Data for Multiple Regions***

On a mobile phone with no pointer dragging functionality, users will face problems in specifying if one or multiple parts need to be selected. For instance, health problems may occur on the left, right or both arms, both arms are separated by body, so how can

a user specifies that the problem occurs on both arm? Making selection on one arm at a time might work, but it is time consuming and not efficient.

#### 2.4.1.3.1 Solution: Use of Drawing Boxes to Represent Regions.

When crosshair moves over to a point within a region such as right arm, both arms will have outer highlighted line box and inner small highlighted box for both left and right arm, this means that both arms are selected. If the crosshair moves into the inner box of one of the arm, then only the inner box of the arm will be highlighted on the mobile screen, which means that the only the arm of that side is selected.

#### **2.4.1.4 Problem: Navigating Through the Record**

A personal health record might include massive amounts of patient data. For a massive health record, viewing or searching for specific health data becomes an issue. With a small screen sized phone, scrolling through the phone screen looking for information from a massive data set is very time-consuming.

##### 2.4.1.4.1 Solution: Document Visualization

Graphically visualizing a health record makes a large and complex set of information easier to assimilate and navigate. With zoom-in and zoom-out features one can solve the small phone screen problem. In addition, to improve speed of navigation, various approaches can be used to visualize data locations, such as categorizing each type of information with different colours and shapes of label boxes, similar to the LifeLine visualization discussed above. Details will be discussed in the implementation section.

#### **2.4.1.5 Problem: Exploring the Screen**

Touch-screen cellphones do not need an indicator to show a location on a screen, but other cellphones do need one.

##### 2.4.1.5.1 Solution: Indicator

Use an indicator such as a crosshair to explore and select on a screen. Exploring mobile phone screens should take minimum amount of time.

#### **2.4.1.6 Problem: "Limited Device" Screen Size**

A mobile phone screen has a limited size. This means that the PPHR must include as much information as possible in a limited space. One example of this limitation is the use of Lists in J2ME. On some phones a list entry can use only one line of text on the screen any characters beyond the limit of a line are truncated. So every list entry must be as short as possible.



#### 2.4.1.6.1 Solution: Display Only Necessary Information

The choice lists for entries consist of more possible choices of short items (rather than fewer choices of more complete, longer terms). When viewing the PPHR content, i.e. the person's health record, each entry should be shown in its entirety. Some extra information which is not necessary for showing can be hidden. Flags may be represented by a single character, can be used to indicate status that will occupy a large section of a line.

#### 2.4.1.6.2 Solution: Graphics for Input and Output

As mentioned above, an image can replace long lists of anatomical locations when selecting the place where it hurts.

On the output side, a graphical representation of the PPHR content can replace more long lists of types of entries, entry dates, etc. This is especially relevant when a user wishes to view only part of the PPHR.

### 2.4.2 The PPHR Record

The health record itself is persistent data stored in the phone memory. All J2ME-enabled phones support a Record Store which is like a very simple database. However, a Record Store which is linked to a specific application will be reset (=disappear) if the application is replaced or deleted. Some phones support file systems (Sun Developer Network, 2010), which would allow for more persistence of data storage. However, the PPHR does not use this, because the Record Store mechanism is more widely supported.

The PPOEHR (Seo, 2009) used an XML template for record entries. However, the XML tags themselves used too many characters for devices (phones) with limited screen space. Based on that, the data format is reduced to the basic name-value pairs. The date and time are required, as in every kind of medical record, and this does lead to problems due to the number of characters required for them.

### 2.4.3 PPHR Record Structure

A PPHR entry is a String like

```
YYYY-MM-DDTHH:MM:SS[.msec]LLLs(S)e(E)|user entry\n
```

Where

YYYY-MM-DDTHH:MM:SS[.msec] - date time of entry. YYYY year, MM month, DD day, T a separator, HH hours 00-23, MM minutes, SS seconds, \n end of line. Currently msec is NOT used.

LLL 3-letter ISO 639-3 code for the language used in this entry

s(S) - single letter flag. s - not yet backed up via SMS, S - already backed up

e(E) - single letter flag. e - entry considered valid, E - entry considered error

| - pipe delimiter

User entry - the selections and notes entered by the user.

The record String uses Java character encoding (UNICODE or UTF-16). However, for transmission via SMS it must be encoded as UCS2 (the SMS code for Unicode) or possibly UTF-8. Records are stored in the J2ME Record Store, something similar to a database which is part of the J2ME specifications and which thus works on almost all mobile phones which support J2ME, even if they do not support a file system.

Records may be added but not deleted.

Notes on individual items:

Person> Name and Given Names elements

The Name attribute has long been a problem for health record systems. This is even more so in Southeast Asia with its huge variety of naming conventions. Western countries usually separate the Name attribute into First Name, Middle Name (or initial), and Last Name (Surname). HL7 v2.5 breaks these down into more subclasses e.g. Family Name consists of possible components Surname, Own Surname Prefix, Own Surname, Surname Prefix From Partner/Spouse and Surname From Partner/Spouse. In contrast, Chinese names traditionally start with the surname, and in Malaysia many Chinese have both a Christian and Chinese Given Names in a variable order. Some Moslem names do not include a Family Name but rather a list of son (or daughter) of ..., which means that the last part of a child's name is not the same as the last part of his parent's (or parents') names, but such names also are not separable into a prefix and surname. Some people have one single word as their Name, e.g. Fauzi or Ryandi.

Google Health uses a single field (login or user name) as its name identifier. Therefore, any choice of name field or fields will match some, but never all systems. We have chosen to divide the name attribute into Surname and Given names, a compromise among all the possibilities. These could be combined into a single field, but they cannot be subdivided into the level of detail offered by HL7 v2.5 for example.

Language

Making health records multilingual has long been a goal of developers. However, the granularity of multilingual support is quite variable. There are two obvious options (and maybe more):

- Select a language for the entire health record. This would mean a one-time choice. It would simplify the record, as any processing package could easily determine the language used throughout the record. For example, the Continuity of Care Record or CCR (ASTM, 2005) contains a single language element at the start, indicating the language of the entire message, as follows.

```
<Language>
<Text>English</Text>
<Code>
<Value>en</Value>
<CodingSystem>ISO-639-1</CodingSystem>
</Code>
</Language>
```

However, the disadvantage is that the user (or users) cannot change his mind or their minds, or select the most appropriate language for each context.

- Select a language for each entry in a health record. This is the approach adopted for the PPHR. Each time a user starts the PPHR, he is prompted to choose one of the available languages for that session. The language code (ISO 639-3) is included in each PPHR entry. This increases the flexibility for the user; a Malaysian user may choose Bahasa Malaysia for his own entries, but his doctor may want to make an entry in English.

But the increased flexibility comes at a cost in standardization. Healthcare communication standards such as HL7 and the CCR are written solely in English, so for a PPHR to make use of these a reverse translation back into English is necessary. Fortunately, this can be done with software, so the user is not burdened with it. Unfortunately, low-capacity cellphones would struggle with the computing load. So the solution is to put the translation packages into the SMS Gateways. The cellphone user only has to send his PPHR via a usual SMS to the gateway provided by his Personal Health Record organization or system, and the translation into an international standard format is done there.

#### **2.4.4 Communications and Backup**

As mentioned, data transferred will be done through a GSM connection. Data will be sent a middleware call MIRTH, MIRTH then will convert the data into either HL7 or CCR coding standard depending on whether the data used by myCare2X or Google Health. Google Health will act as a backup server for all the patients data. As discussed in the sections on standards, much standardisation in healthcare communications comes via message standards such as HL7 and the CCR. The PPHR vocabulary can be translated into CCR and/or HL7 v2.x format for data transfer to Google Health or myCare2x.

### **2.5 Implementation of PPHR**

#### **2.5.1 Software Language**

Most cellphones support J2ME Java version 2 Micro-Edition; therefore, that is chosen as the programming language.

#### **2.5.2 Integrated Development Environment**

NetBeans is used as a mobile phone emulator and compiler of J2ME. NetBeans has the advantage of being free; it also provides various samples and templates for midlets.

#### **2.5.3 User Languages**

The choice lists for data entry (see below) can be translated into other languages. Until September 2010, the lists have been translated from the original English into German (Deutsch, deu), Chinese (Mandarin, zho) and Malay (Malay, msa). User is asked to select a language once the application starts, before the user could do anything else. The language codes are taken from ISO 639-3.

#### **2.5.4 Lists**

The basic entries in the lists are derived from the ICPC2 coding system, with some modifications as needed. Users are allowed to add their own text after selecting the basic content of an entry. The lists provide up to 5 levels of choices. Example of problem list selection can be seen in Figure 2-4 and detail of list design and implementation will be explained in Section 3.4.1. Listing in PPHR is rearranged so that items listed from top to bottom will be according to the importance and amount of usage of the item. As mentioned, data entry by free text can be replaced to a large extent by selections from lists of choices. For primary health care the ICPC2 standard

(more specifically ICPC2e version4 WONCA, 2010) provides such lists which include most of the entries commonly used in primary care.

The ICPC2e v4 lists are divided into chapters

A General

B Blood, blood forming

D Digestive

F Eye

H Ear

K Circulatory

L Musculoskeletal

N Neurological

P Psychological

R Respiratory

S Skin

T Metabolic, endocrine, nutrition

U Urinary

W Pregnancy, family planning

X Female genital

Y Male genital

Z Social

And each chapter is divided into components

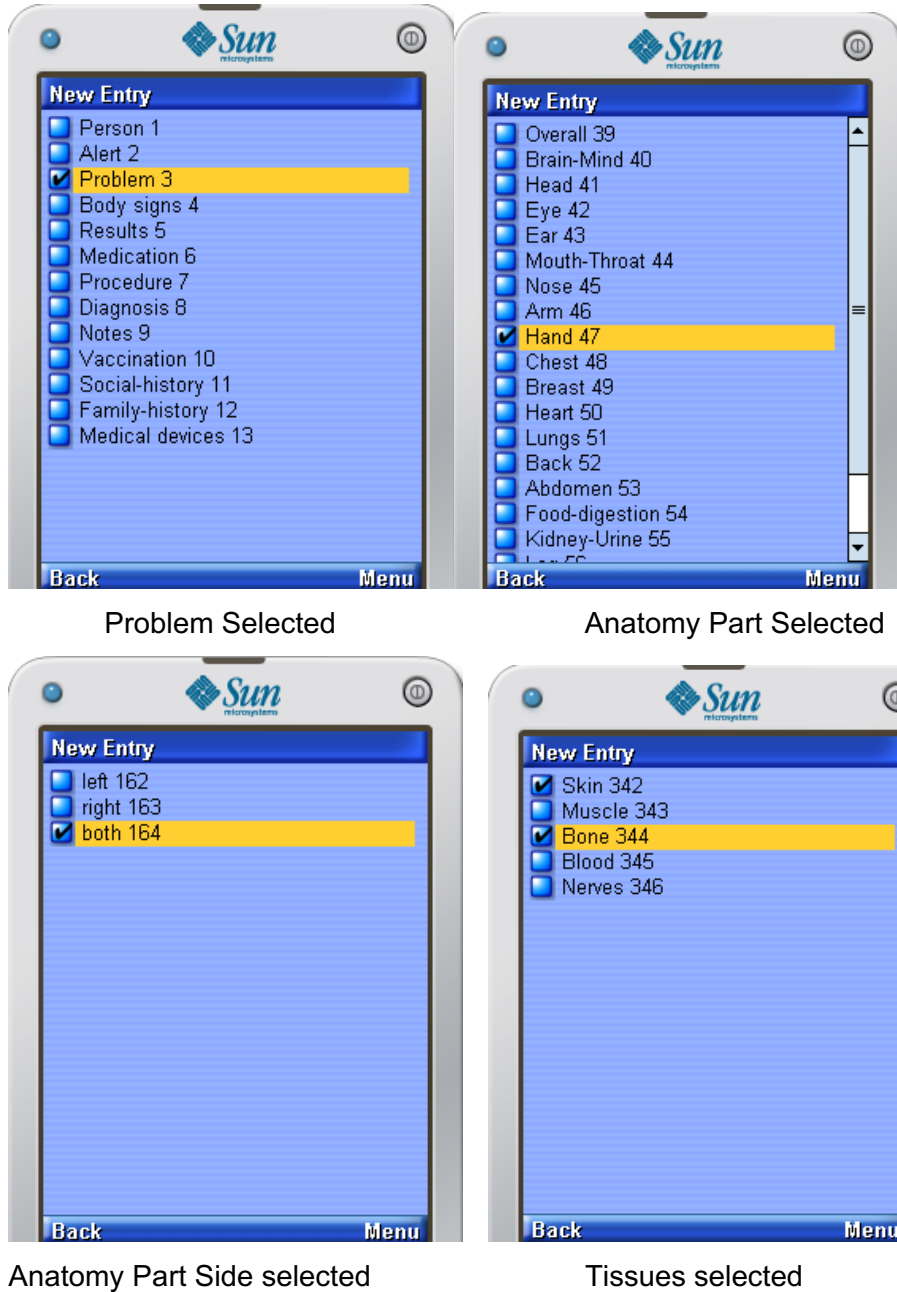
1. Symptoms, complaints
2. Diagnostic, screening, prevention
3. Treatment, procedures, medication
4. Test results
5. Administrative
6. Other
7. Diagnoses, diseases

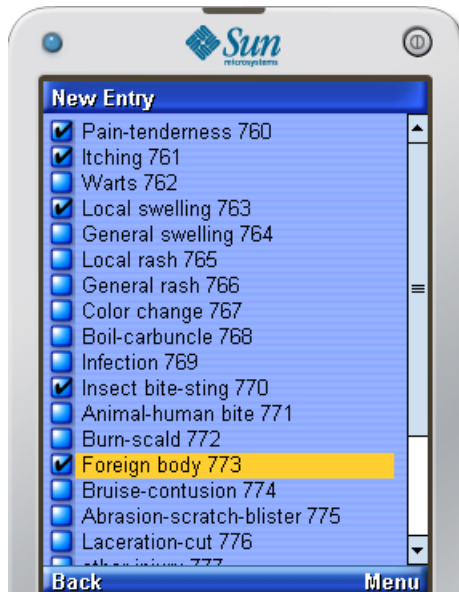
Each item has a code derived from the chapter and component identifications. To find a particular item, a user can navigate through the chapters, then the components, or the other way.

In the PPHR we also step through various categories (or levels) to find a desired item. The path from each level to the next depends on the content at each level. For example, for a Problem (i.e. health problem), the top-level category is Problem .

Under that is the anatomical location(s), the part or parts of the person affected. Depending on the location, the next level can be the side (left, right, middle, both / whole). The next level may be the type of tissue (skin, muscle, nerves, blood, and bone) affected at the location. The last level would be the types of afflictions or problems which can affect that tissue at that location. Example above is described in Figure 2-4.

**Figure 2-4: Problem Selection by List**





Afflictions/Problems selected

## 2.5.5 Data Input of PPHR

### 2.5.5.1 Text Input Using J2ME Frame Class

This section describes the text input in PPHR, text input includes list of choice groups and text field. See Section 3.5 for examples of how the graphic mode works. List Input The PPHR is mainly showing ICPC2e items in list. Users are allowed to select either one or more item from the list, and then go to next list if there is any otherwise if the items selected will be display on screen with a text field to input additional data.

#### 2.5.5.1.1 Extra Data Input

Users can also input extra data at the end of the listing before a new entry has been saved in order to include more health information. Data entry selected from a list or graphics will be displayed in a form with a text box to add extra comments. Refer Results section.

#### 2.5.5.1.2 Mark Error on Entries

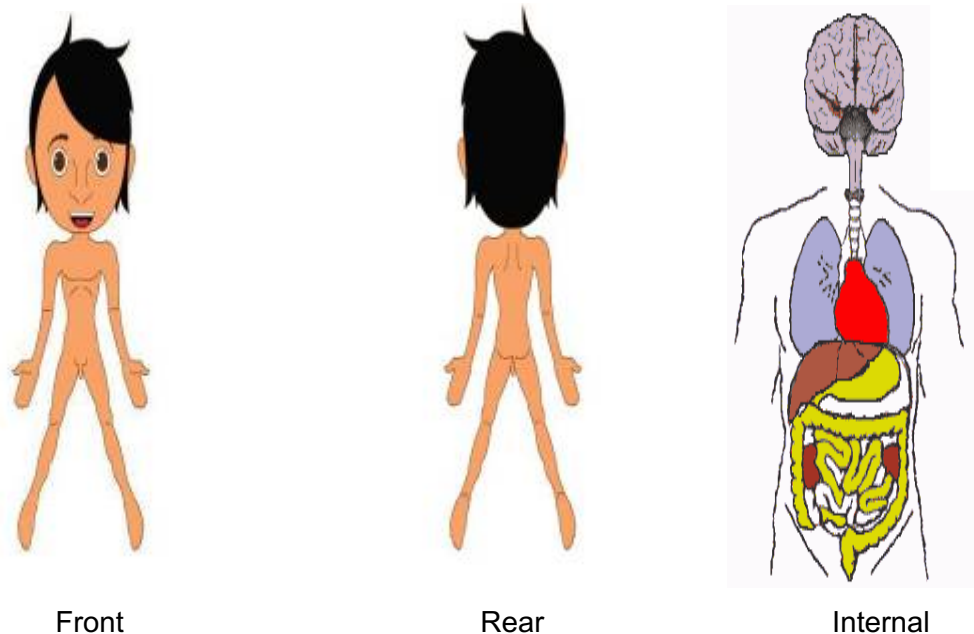
In the view records screen, users are allowed to select a specific entry and mark errors on it. The Mark Error function is included in the Menu at the bottom right of phone screen. An error flag will be marked on the corresponding entry after users chose to save the error flag. Refer Results section.

### 2.5.5.2 Graphics Input

Since a mobile phone screen has a limited size, a single large image showing all anatomical body locations at once would be impractical. So the anatomical diagram must be split into at least three: a front and a rear external body view, and a view of internal organs, see Figure 2-5. Each physical part shall be clearly presented, size of each physical part will not be normal but is according to the ease of grouping regions and the ease of viewing by users. As mentioned earlier, an image can replace long lists of anatomical locations when selecting a body part with problem such as place where it hurts. See Section 3.5 for examples of how the graphic mode works.

#### 2.5.5.2.1 Split Anatomy Images

**Figure 2-5: Anatomy Image in Different Views**



Front view anatomy includes: Head, Ear, Eye, Nose, Mouth-Throat, Chest, Breast, Abdomen, Genital, Arms, Hands, Legs, and Feet.

Rear view anatomy includes: Neck and Back.

Internal anatomy includes: Mind, Brain, Lungs, Heart, Digestive Systems and Kidney.

#### 2.5.5.2.2 Use of Colour and Line Boxes to Specify Selected Areas

This is done according to the design of selecting multiple regions. Square boxes will be drawn if body parts are separated such as arms. The square box will only show on arms region if arms are selected. The inner box will indicate left or right arm while the outer box will indicate both arms. Refer Results section.



### 2.5.5.2.3 Only Relevant Parts Are Selectable

The use of a crosshair to explore and select on a screen is common, but this approach is slow, especially when users try to get the crosshair from one end of the screen to another, for example, feet to head. So this approach is not used. One body part in an image will be selected by default, pressing the up and down of the arrow key on the cellphone will select previous or next body part. Left and right arrow key will select sides of the selected body part. This approach lets the user only traverse through selectable body parts without having to waste time exploring irrelevant locations.

Approach:

Front and rear external anatomy and internal organs are represented by a 3D array.

int[][][] boxPct =

```

{ { { -1, -1, -1, -1 }, { -1, -1, -1, -1 }, { 10, 2, 80, 75 } }, // Overall. mid
  { { -1, -1, -1, -1 }, { -1, -1, -1, -1 }, { 38, 1, 27, 4 } }, // Mental. mid
  { { 32, 6, 18, 16 }, { 51, 6, 19, 16 }, { -1, -1, -1, -1 } }, // Brain. right left
  { { 20, 8, 29, 10 }, { 53, 8, 29, 10 }, { -1, -1, -1, -1 } }, // Head. right left, no middle
  { { 32, 24, 12, 5 }, { 58, 24, 12, 5 }, { -1, -1, -1, -1 } }, // Eye. right left, no middle
  { { 18, 24, 9, 6 }, { 75, 24, 9, 6 }, { -1, -1, -1, -1 } }, // Ear. right left, no mid
  { { 45, 25, 6, 6 }, { 51, 25, 6, 6 }, { -1, -1, -1, -1 } }, // Nose. right left, no mid
  { { 42, 32, 9, 4 }, { 51, 32, 9, 4 }, { -1, -1, -1, -1 } }, // Mouth-Throat. right lf, no
mid
  { { 40, 38, 7, 7 }, { 54, 38, 7, 7 }, { 47, 38, 7, 7 } }, // Chest. rt lf mid
  { { 42, 39, 7, 5 }, { 52, 39, 7, 5 }, { -1, -1, -1, -1 } }, // Breast. rt lf, no mid
  { { 23, 46, 14, 6 }, { 64, 46, 14, 6 }, { -1, -1, -1, -1 } }, // Arm. rt lf, no mid
  { { 10, 52, 15, 7 }, { 76, 52, 15, 7 }, { -1, -1, -1, -1 } }, // Hand. rt lf, no mid
  { { -1, -1, -1, -1 }, { -1, -1, -1, -1 }, { 44, 42, 19, 16 } }, // Heart. mid
  { { 26, 38, 15, 19 }, { 65, 38, 11, 19 }, { -1, -1, -1, -1 } }, // Lung. rt lf, no mid
  { { 54, 38, 7, 15 }, { 40, 38, 7, 15 }, { 47, 38, 7, 15 } }, // BACK pic. Back. rt lf mid
  { { 43, 46, 5, 6 }, { 53, 46, 5, 6 }, { 48, 46, 5, 6 } }, // Abdomen. rt lf mid
  { { -1, -1, -1, -1 }, { -1, -1, -1, -1 }, { 26, 61, 47, 31 } }, // Food-intestine. mid
  { { 30, 74, 8, 10 }, { 62, 74, 8, 10 }, { -1, -1, -1, -1 } }, // Kidney. rt lf, no mid
  { { 45, 51, 5, 4 }, { 50, 51, 5, 4 }, { -1, -1, -1, -1 } }, // Genital female. rt lf, no mid
  { { 45, 53, 5, 4 }, { 50, 53, 5, 4 }, { -1, -1, -1, -1 } }, // Genital male. rt lf, no mid
  { { 22, 63, 20, 6 }, { 60, 63, 20, 6 }, { -1, -1, -1, -1 } }, // Leg. rt lf, no mid

```

```
{ { 12, 70, 20, 6 }, { 70, 70, 20, 6 }, { -1, -1, -1, -1 } } }; // Foot. rt lf, no mid
```

Explanation:

- boxPct[][][] - first dimension is list of rows (body parts)
- Second dimension - each row consists of 3 rectangles (g.drawRect(...)) for right left middle anatomy parts
- Third dimension - the (x y width height) for each rectangle
- Numbers are in PERCENT of SCREEN WIDTH or HEIGHT. Width is left-right, height is top-bottom
- -1 means not a (visible) box

## 2.5.6 Display (Output) of the PPHR

### 2.5.6.1 Textual Display

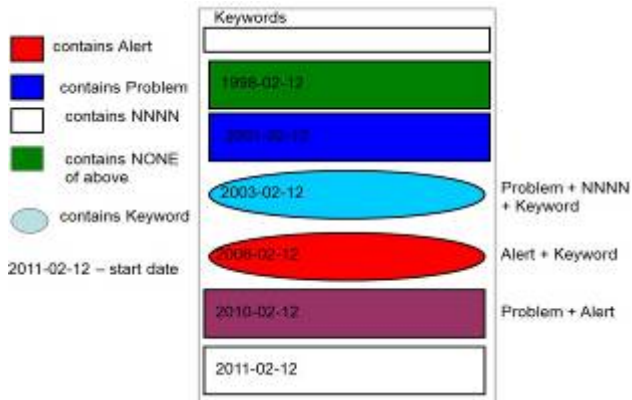
#### 2.5.6.1.1 Display Only Necessary Information

The date and time alone are 19 characters long, and there are two status flags (Sent or not sent to SMS gateway backup, Error or not error), so these together may occupy a large section of a line. The time component is not displayed because of this. This omission saves 9 characters per entry. This does make the unique identification of each entry inexact, but that problem is solved another way.

### 2.5.6.2 Graphical Display

#### 2.5.6.2.1 Visualize Health Record

A graphical representation of the PPHR content can replace longer lists of types of entries, entry dates, etc. This is especially relevant when a user wishes to view only part of the PPHR. Brief information of health records will be presented on the first screen of record view. As shown in Figure 2-6, the health record will be categorized by the type of information such as Alert, Problem, Problem + Alert, or with keywords using separate colours and shapes of boxes. Record view screen includes keyword input box and a list boxes in different shapes and colours labelled with dates. This approach allows users to quickly estimate the location of their desire information by the dates, colours and shape of boxes. The design draft is shown in Figure 2-6.

**Figure 2-6: View Health Record**

## 2.6 Testing of PPHR

Evaluation form is prepared to evaluate the usability of the PPHR; it includes remarks from users for all the commands available in PPHR such as the initiation command GO , Make new entry , View all , View alert , View selected (Text and Graphic mode), Mark error , PPHR->SMS , Help , Back , and Exit . The ratings are range from 1-5 for the satisfactory of using PPHR, which 1 means very dissatisfied, 3 means neutral and 5 means very satisfied. Details of the PPHR evaluation form are in Appendix A

Twenty participants will be chosen to evaluate PPHR. Participants include people who have IT knowledge, people who are familiar with cellphones, people who are often involved in healthcare, and people who are not familiar with cellphones.

## Results

The introduction discussed the shortage of HIS in Malaysia. In order to verify the findings, interviews were conducted to establish the current status of HIS in Malaysia.

### 3.1 Information from Interviews about Health Records in Malaysia

#### 3.1.1 Interview 1: Mr. Ngui How Chen

Position : State Medical Assistant Head of Sarawak Healthcare Department (Ketua Penolong Pegawai Perubatan Negeri, Jabatan Kesihatan Negeri Sarawak), currently working in Sains

Location : Sarawak General Hospital

Date : N/A

Statements: THIS is not complete, has been used in several hospital like Selayang. TPC is used in Sarawak and Johor, TPC main centre is in Sibu, it is aim for rural clinic. TPC uses satellite transmission, bad transmission at heavy rain. Records are stored in patient folder. Health record only will be kept for 7 years from last attendance. Patients below 7 years old, have school health service. Health record is kept by themselves or school. Health records are sent to school for periodically check children. At the moment, Malaysia does not use any system that enable patient to retrieve their health information from the Internet. Health record below 7 years old (Figure 1-3) is important for immigration and the worker s health records are kept by individuals. Patients do not own specialize case health records, they can keep none-specialize case health records. In order to obtain information of specialize case health record; patient will need to apply for a summary written by doctor/specialist for the corresponding health information.

#### 3.1.2 Interview 2: Madam Goh Teck Wang

Position : Nursing Sister of Sarawak General Hospital, Kapit General Hospital, Sibu General Hospital, Sibu Poliklinik, London Fatality Clinic Sibu.

Location : Sibu General Hospital

Date : N/A

Statements: The specialist doctor has a computer. In Sibu hospital, specialist can check patient record through the computer. Sibu General Hospital uses TPC. For

health records, what usually happen among all the government hospitals I had worked for, if a patient need to obtain his/her health record from another government hospital, person responsible need to ring up and ask for it. This only work in office hours, otherwise patient cannot retrieve health record as no one is working. For the specialize case health record, the summary content only the latest admit, the content is quite complete, but it does not include much of history information, almost none.

### **3.1.3 Summary of Interviews**

From the interviews and literature studies, it is obvious that HIS is not popular among healthcare providers in Malaysia. The importance of the accessibility and the availability of health records are being neglected. Most of the healthcare providers in Malaysia are still using paper-based documents. The HIS currently being used by Malaysian healthcare providers, many of them are not complete, and do not handle health records very well. Because of the weather in Malaysia, TPC which is used in rural areas is not too practical as it influenced by weather. Current health record handling systems are very inefficient. It might cause a waste of time and money. According to the interviews, there is no mention that there will be a major investment in hospital systems and EHR is also not planned to be widespread in Malaysia. There is no better solution for patients to access health records with mobile technology yet.

## **3.2 Structure of Proposed PHR System Including the PPHR**

Figure 3-1 shows a mobile health system including communications, input, output, storage and standardizations. The main focus of this research is to improve the input section and visualize the entire PPHR record so that the massive records stored in cellphone can be navigated easily by users. The PPHR is used to collect, store and upload data for storing on central servers. To improve efficiency of inputting and navigating data, a GUI version of PPHR is one of the main achievements of my research. From Figure 3-2, the diagram shows the whole data collection system, and this research work concerns the PPHR itself and not the LHR.

Figure 3-1: Mobile Health– PPHR (from Seldon, personal communication 2010)

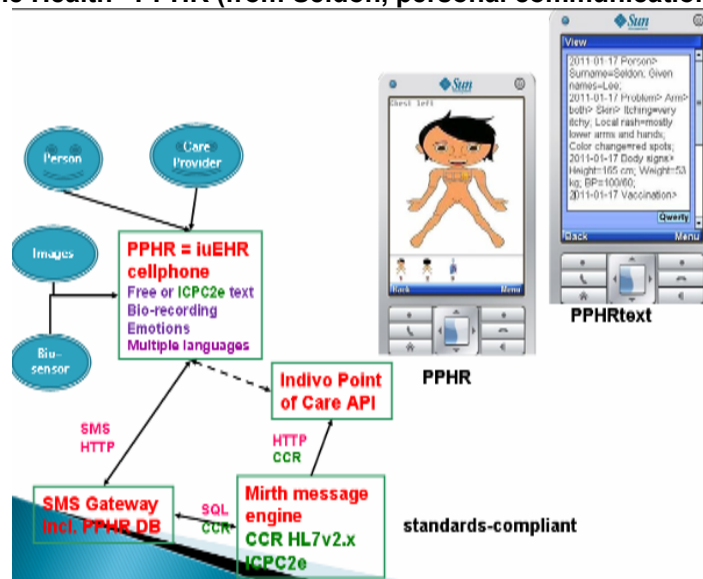
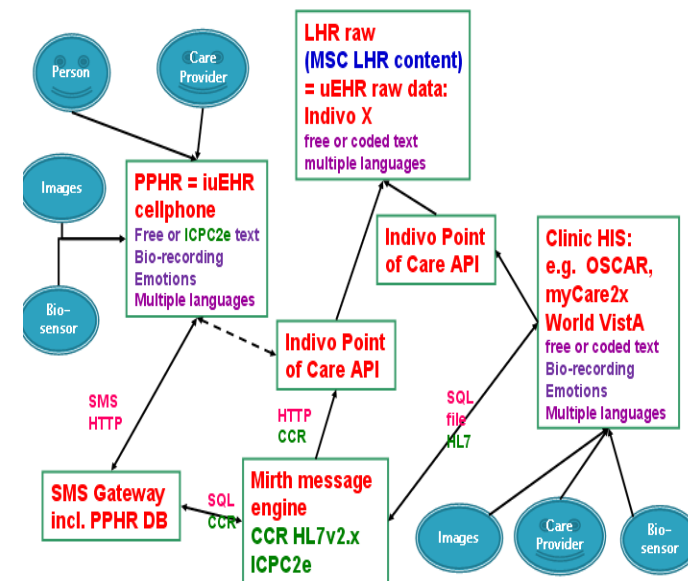


Figure 3-2: Data Collection System– PPHR (from Seldon, personal communication, 2010)

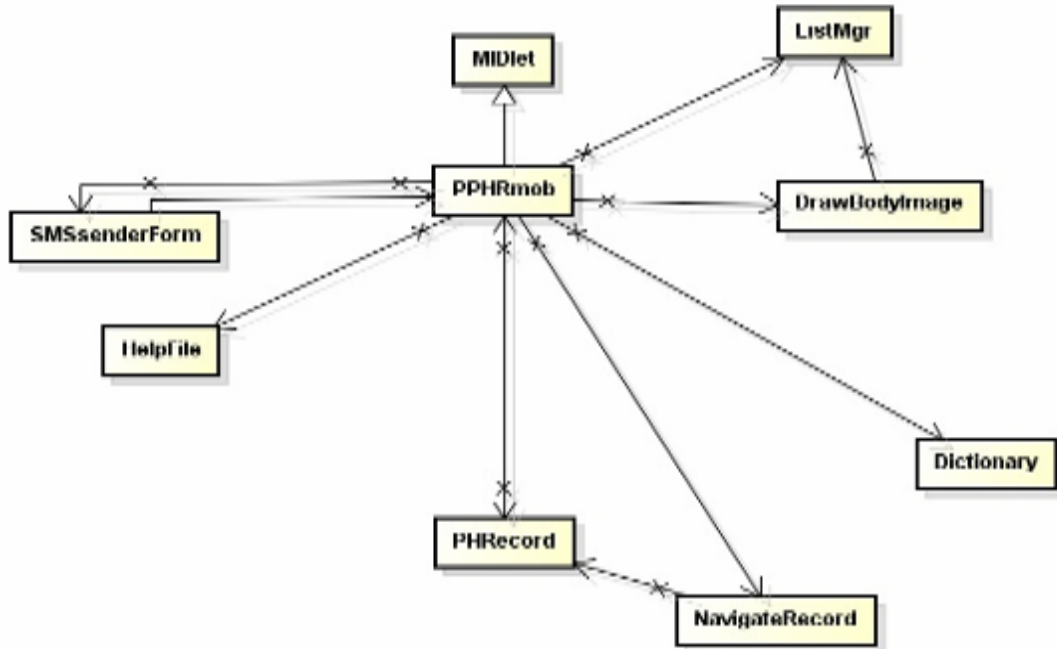


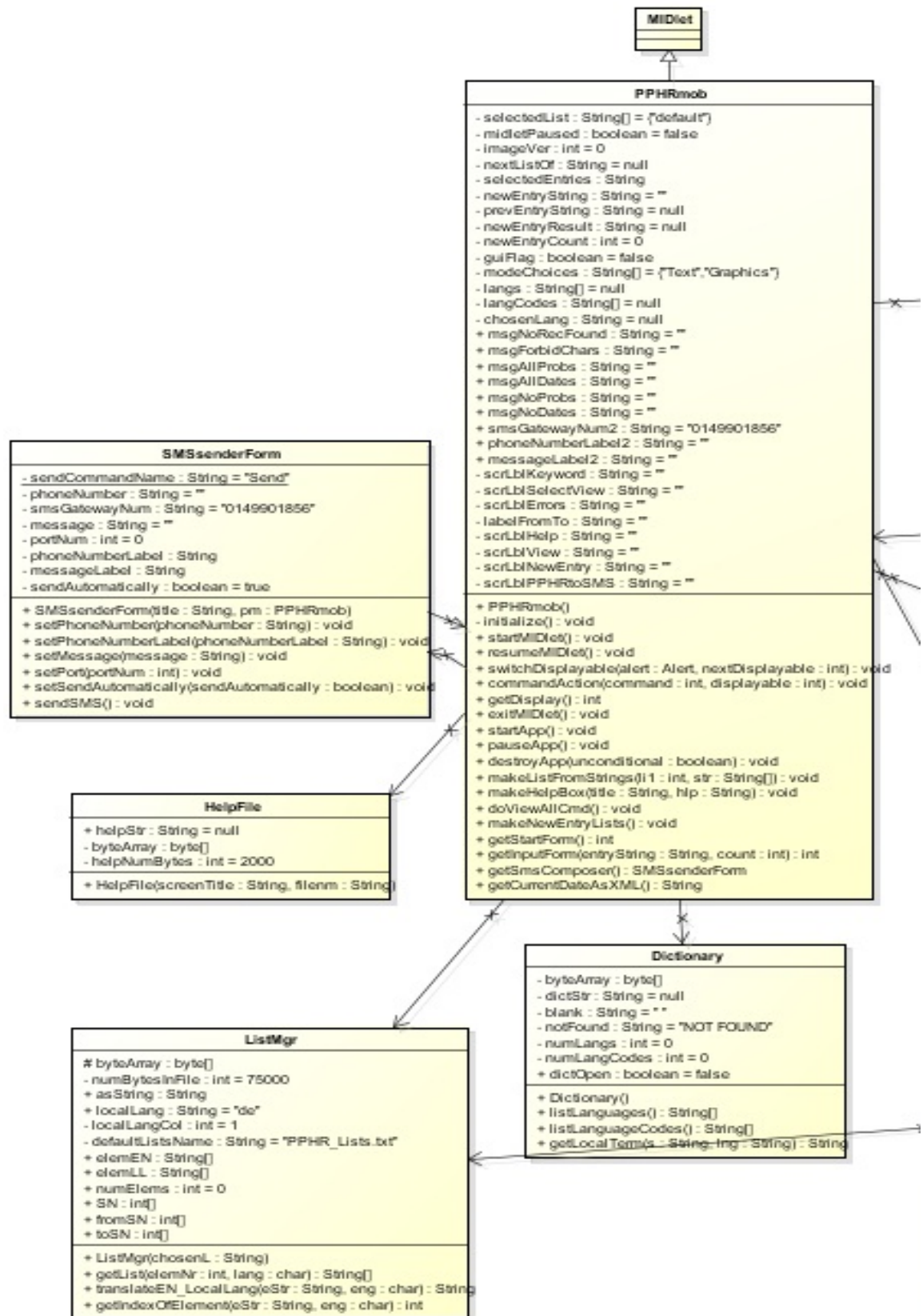
### 3.3 The PPHR Software Package

This section describes the usages of each class file, descriptions of important methods and attributes are given. The PPHR package consists of eight class files, help files, and image files. Image files are located in a folder named `img` and all help files are stored in folder `Help`.

### 3.3.1 Software Architecture

#### 3.3.1.1 Class Diagrams









### *3.3.1.2 Description of Classes*

**PPHRmob.java** PPHR starts in this class, it is a main midlet class to declare interface classes such as commands, forms, and lists. It handles switching of displayable classes and calling of other classes.

Important attributes:

- **selectListMgr (ListMgr)** This attribute gets created lists of ICPC2e coding system items according to specific elements serials and the list is used to display on cellphone screen. It retrieves a list from an element serial to another element serial in chosen language. selectListMgr can retrieve translated list item to specific language as string and also index of specific element.
- **PHRec (PHRecord)** PHRec is a type of PHRecord, it handles all the records stored in the PPHR. In PPHRmob.java, in order to check whether there is any record available, PHRec.asString is compared, asString in PHRecord stores record data. If PHrec.asString is not null, it means that records are not empty. If there is a record, a function will be called to display all records on screen. Another important usage of PHRec attribute in PPHRmob.java is to specify whether an inserted record is an alert type of problem type when creating a new entry. Another functionality of PHRec attribute in this class is to encode record data to byte array and store it in record store. While PPHRmob.java shows data on screen, it makes use of PHRec to remove time and flags to shorten the record string for easy viewing. PPHRmob.java class also need PHRec attribute to retrieve records of different types such as alert or problem type, records starting from and to specific dates are also retrieved by using this attribute. For more details about PHRec of PHRecord type, see PHRecord.java.
- **theImage (DrawBodyImage)** Class makes use to this attribute to get elements and names of a selected body part.
- **vRec (NavigateRecord)** vRec is a NavigateRecord type to get elements of selected entries for either viewing or expanding purpose. See NavigateRecord.java for more details.
- **help (HelpFile)** Class uses help attributes to display text box filled with instruction guides of specific PPHR function.
- **selectedList (String[ ])** selectedList[ ] is used to store list of items return from selectListMgr.

- nextListOf (String) This attribute indicates whether next showing list is a Problem list or a Procedure list, only for GUI version.
- selectedEntries (String) Stores selected entries to view in record navigation.
- newEntryCount (int) Stores count of new entries.
- guiFlag (Boolean) This attribute is to indicate whether PPHR mode selected is in text or GUI mode. guiFlag equals to 1 if GUI mode is selected, otherwise 0.
- dictn (Dictionary) This attribute is used in this class to get and list language code, and to get local terms for available commands according to specific language.
- langs (Strings[ ]) Stores language names from dictn (Dictionary).
- langCodes (String[ ]) Stores language codes from dictn (Dictionary).
- chosenLang (String) Language chosen to run PPHR. chosenLang is according to langCodes, en , de , zh , msa .
- smsGatewayNum2 (String) Default phone number of SMS gateway.

#### Important methods:

- PPHRmob() Constructor of PPHRmob class to declare PHRec, dictn and get list of languages names and codes. It also checks whether languages file works properly.
- makeListFromStrings(List li1, String[] str) Convert array of string items to list items.
- makeHelpBox(String title, String hlp) Creates a help box to display help information with commands to exit, view all records, and back to previous screen.
- doViewAllCmd() Puts the PHRec.asString into viewTxtBox and displays it.
- makeNewEntryLists() Create a ListMgr (selectListMgr) to load and prepare lists for selection. Fill the newEntryList screen (List) with the first items in the selection lists.
- getCurrentDateAsXML() Gets current system date time as variable Date d, creates XML dateTime variable string dt from variable Date d, except millisecond value.

**PHRecord.java** Process the record file which record string uses Java character encoding (UNICODE or UTF-16). The records are store in Java Record Store. Chinese characters are encoded UTF-8 as it only persist in the Record Store. Records can be

added but not deleted and records with error can be flagged as erroneous. This class also keep track of the index of Alert, Problem entries if existed.

Important attributes:

- `ehrRec (RecordStore)` RecordStore type, used to open Record Store, get records and number of records.
- `defaultEHR (String)` Assigned as Record Store name, "personEHR.txt" in PPHR.
- `asString (String)` The whole PPHR record data is stored in asString as a single string.
- `pipe (char)` As a delimiter of record string.
- `flagError (char)` Set as E by default, to indicate a record entry which is marked as error.
- `entryTypeProb, entryTypeAlert, entryTypeDefault (char)` `entryTypeProb` equals to P, `entryTypeAlert` equals to A and `entryTypeDefault` equals to N by default. PHRecord uses these attributes to compare type of each record entry. These attributes will be stored in `entryType[ ]` according to specific condition. These attributes are important for NavigateRecord class to keep track of each entry type. See NavigateRecord for more details.
- `keyWdYes (char)` Set to K by default, PHRecord class uses this attribute to indicate whether an entry contains keyword. This attribute is used to store in `keyWd[ ]` if keyword exists in the same index of array item.
- `dateTimeLgt (int)` Indicates number of chars in dateTime. Class uses it as an index to delimit substring from a record string.
- `timeLgt (int)` Indicates number of chars in time. Class use it as an index to delimit substring from a record string.
- `langCodeLgt(int)` Indicates length of ISO639-3 language codes. Class uses it as an index to delimit substring from a record string.
- `flagsLgt (int)` Indicates number of char flags, currently 2 for s[sent]e[error]. Class uses it as an index to delimit substring from a record string.
- `maxNumNewEntries (int)` Set to 50 by default. Set length of following arrays. Set to 50 means can make max 50 new entries per session.
- `entryStartPt (int[ ])` Array of start indices of each entry in whole PHR 'asString'. To divide PHR record into blocks for quick searching, we use the indices of the entries as used in arrays `entryStartPt[ ]`.

- entryType (char[ ]) Array of entry types n p a, one for each entry.
- keyWd (char[ ]) Array to show if keyword is present in each entry or not.

Important methods:

- PHRecord(String filename, PPHRmob p1) Constructor looks in RecordStore for existing record. If found, it reads the record and converts it to the variable asString.
- addToEHRfile(String toAdd) Encode PPHR asString into byte array with Java standard (UNICODE, alt UTF-8). The PPHR is always stored as record ID = 1 in RecordStore. If there is already a record in it, replace that with entire PHRec.asString or else add new record to RecordStore.
- getEntriesWith(String s) Use to search for keyword. Finds all entries containing String then sets the keyWd[ ] according to entry index to keyWdYes.
- getEntriesProblemAlert(char pa, int fromEntryNum, int toEntryNum, boolean includeAllProbLine) Finds entries of type 'p' or type 'a' from index fromEntryNum to toEntryNum, then get the record entry with type p or type a .
- getEntryDates(int fromEntryNum, int toEntryNum, char lgt, boolean includeAllDateLine) Finds dates of all entries (including ERROR ones), trim the dates according to variable lgt either d - date, m - month, h - hour or a whole date time. Date string is taken from a substring of asString.
- makeListOfSelectedEntries() Gets each line of the PPH record (asString). If looking for Problems, then store the Dates of the Problem entries. Look for entries with dates within a range of the Problem Dates, i.e. from Problem Date - range to Problem Date + range. If looking for Dates, this looks for entries with dates between FromDate and the corresponding ToDate. IF looking for Keywords, then search the output of the Date search and delete entries which do not have any chosen keywords.
- makeViewString(String s, int inclError, int flagsOn) Removes time and maybe flags from the input String s to shorten the string for viewing.
- getEntriesForSMSbackup() Gets each line of the PPHR record (asString). Get 2 char from end of date-flags data for the not-sent/sent flag (s or S) if s (not sent). Adds line to output StringChanges 's' to 'S' in line to indicate Sent status. This function also includes the name (Surname, Given names) and "Date of Birth identification of every SMS.

- `errorFlagToggle(int idx)` Each entry has an error flag - the char JUST BEFORE THE | which separates tags from content. The flag 'e' means the entry is correct, 'E' (=flagERROR) means the entry is wrong. This method searches through the total `asString` for the pipe in entry `idx`, it then toggles the char just before the pipe between 'e' and 'E'.
- `resetBlockFirstEntry()` This method is important to reset block first entry in record navigation. Whenever the number of record entries changed, or expanding or searching of blocks, this method need to be called in order to ensure the correct arrangement of entry blocks in record navigation. See `NavigateRecord.java` for more details.

**ListMgr.java** Manages lists of selectable elements for new record entries. The lists are created from file `PPHR_Lists.txt` which the `PPHR_Lists.txt` must be UTF-8 encoded. Each line of `PPHR_Lists.txt` contains serial number, English term, German term, Chinese term,(etc.),pointer to start of next list, pointer to end of next list. These are stored in arrays `SN[]`, `elemEN[]`, `elemLL[the chosen local language]`, `fromSN[]`, `toSN[]`. The `elemEN[]` and `elemLL[]` store the terms + SN at the end of each term. SN is used to find next lists for those terms which point to other lists

Important attributes:

- `numBytesInFile (int)` Set to 75000 by default, it must fit `PPHR_LISTS.TXT`. It is use to create a byte array of 75000 bytes size.
- `asString (String)` `asString` stores byte array string converted from `PPHR_LISTS.csv`
- `localLang (String)` Code for language, set to `de` by default. Chosen language for PPHR will be assigned to `localLang`.
- `localLangCol (int)` Indicates which column number of the local language in `PPHR_LISTS.csv`
- `defaultListsName (String)` Default name for PPHR lists. Default for current PPHR is "`PPHR_Lists.txt`".
- `elementEN, elemLL (String[ ])` String array storing list of element in English or other local languages.
- `numElemes (int)` Number of elements in list.

- SN, fromSN, toSN (int[ ]) Serial numbers of list, from serial number and to serial number. Class use these variables to decide which element should be listed in order.

Important methods:

ListMgr(String chosenL) Act as constructor, reads the file PPHR\_Lists.csv as a byte array (byteArray) then converts byte array to String asString. This method also creates arrays elemEN, elemLL, SN, fromSN, toSN and then fills all these arrays.

getList(int elemNr, char lang) This method gets the index of an element, checks the fromSN and toSN arrays to see if elemNr leads to another list. If yes, it returns the array of Strings fromSN toSN either in English or other languages.

translateEN\_LocalLang(String eStr, char eng) Translates between English word or phrase and local language.

getIndexOfElement(String eStr, char eng) Gets index of string element of record string in either English list or local language list.

**DrawBodyImage.java** To present a list a body parts in graphic by drawing body and separate body regions. Body is represented in 3 views: external front, back and internal front. Body part sides include: left, right, middle and all. Light grey boxes are drawn around selectable boxes and a box is highlighted if the corresponding body part is selected. Selected body part will lead to the next PPHR list according to the entry type: problem or procedure.

Important attributes:

- langList (ListMgr) Selection list of ICPC2e items.
- imageList[ ] (String) Store name of image name with extension in this array for front, rear and internal body view.
- bodyViewIamge (int) Shows which image from imageList[] is displayed. Values are 1 2 3 indicating front, rear and internal view correspondingly. Value input is done by keypad of a cellphone.
- sideList, prbList (String[ ]) sideList stores name of body part sides, e.g. left, right, middle, and prbList stores name of body part, e.g. hands, heart, arms.
- nextEntry (String) This attribute is either Problem or Procedure. Since Problem and Procedure points to the next different list, class has to keep track on which next list to display according to this attribute.

- `prbPartName (String)` Store body part s name.
- `sideName (String)` Store the name of body part side.
- `stringNum (String)` Side index in string.
- `partNum (String)` Part index in string.
- `currentLabel (String)` Store current selected body part name and side name.
- `sideIndex (int)` Index number for body part side.
- `selectedElement (int)` Element of selected body part side.
- `partIndex (int)` Index number for body part.
- `partElement (int)` Index number for selected body part.
- `boxPct (int[ ][ ][ ])` This attribute stores information about each body part, and whether each side is available. This is important to identify selection of body part and side.
- `box (int[ ][ ][ ])` Contains the rectangle coordinates as pixel numbers. This attribute is important for drawing selection boxes on anatomy image.
- `anatPartInImage (int [ ])` List of which image each box row is in.
- `maxRowsInImage (int [ ])` Number of rows of body parts in each of 3 images.
- `partStr, sideStr (String[ ])` Identical to the entries in `PPHR_List` and in same order as `boxPct[][][]`.

#### Important methods:

- `DrawBodyImage(ListMgr selList)` Contrustor using the `ListMgr` from the calling module `PPHRmob`. Assign pixel coordinates to `box[][][]` and then fill `maskarrays[]` with light yellow colour for highlighted selection in `g.drawRGB`. It also finds number of body parts in front, back and internal view.
- `getElementOfPart(String partName)` Gets index number of body part from `PPHR list` and set label of the body part to current language.
- `getElementOfSide(int partIndexNum, String side)` Gets index numbers of specific body part side from `PPHR list`: left, right, middle, all. Append side name to `currentLabel`.
- `setCurrentLabel(String part, String side)` Set position index number and name for same part name of procedure and problem.
- `CreateScaledImage(Image imgOldImage)` Rescale Image to fit on mobile phone screen.



- `paint(Graphics g)` Load size rescaled image of current view, draw rectangular regions, highlight and set label for selected body part.

**NavigateRecord.java** To visualize health records stored into blocks with date ranges. This class provides features of selecting health data from selected date range and display them. Search health records by using keywords. Alert, Problem, Keyword or combinations are presented in different colour of blocks on screen for easier data identification.

Important attributes:

- `phRc (PHRecord)` PHRecord type, class use this attribute to get `asString`, `blockFirstEntryI`, `entryType` and `keyWd`. This attribute also sets `searchFromEntryI` and `searchToEntryI` in PHRecord.
- `kwLabel, cgLabel (String)` Set keyword and ChoiceGroup labels.
- `firstSelectedEntryI, lastSelectedEntryI (int)` First and last selected entry of blocks.
- `alertFound, probFound, keyFound (int)` Indicates whether alert, problem or keyword found in an entry. 0 means no.

Important methods:

- `NavigateRecord(String title, PHRecord phR, String kw, String fromT)` Setup labels and keyword text field.
- `setInitialData()` This method is only called the first time navigate record is called. It resets some attributes such as keyword found status, `searchFromEntryI` and `searchToEntryI`. It also resets blocks to cover whole records and initialize `keyField` to blank.
- `displayBlocks()` Displays the Form with keyword Textfield at top and list of blocks and their types below.
- `getFirstLastSelectedEntryI()` Gets the first and last selectedBlocks from the ChoiceGroup, then finds the new entry start index and checks the range.
- `expand()` This method is called after `getFirstLastSelectedEntryI()` as this method only expand if there is at least one block selected. This checks to see if there is a keyword and then refreshes the screen to a new list of blocks according to previously selected blocks.

- `getEntriesToView()` This comes after `getFirstLastSelectedEntry()` with Command 'view selected', this method checks to see if there is a keyword. If no keyword wanted, or if keyword is present, gets that entry and adds it to output String.
- `checkType(int blockIndex)` This checks the entries in block number `blockIndex`, finds their types - alert A, problem P, none N - and whether they contain a keyword (K N), then gets the corresponding image for the type.
- The images are stored in `img/` folder. Image label of Alert - `typeA.png`, Problem `typeP.png`, Keyword `typeK.png`, Alert+Problem `typeAP.png`, Alert+Keyword `typeAK.png`, Problem+Keyword `typePK.png`, Alert+Problem+Keyword `typeAPK.png`.
- `searchKeyword()` Searches for keyword, which was entered in `keyfield`, in all PHR entries. If it finds keyword in an entry, sets the `phRc.keyWd[]` element to 'K' meaning 'found in this entry'.

**Dictionary.java** Opens and reads `CommandDict.txt` which is source of translations for PPHR commands and messages.

Important attributes:

- `dictStr (String)` Store string of dictionary file `CommandDict.txt` without comments.

Important methods:

- `Dictionary()` As a constructor, read dictionary file as byte and convert to string assign to `dictStr`.
- `listLanguages()` Looks at the "Languages" lines of `CommandDict.txt` and return a list of Strings containing languages.
- `listLanguageCodes()` Looks at the "Languages" lines of `CommandDict.txt` and return a list of Strings containing language codes.
- `getLocalTerm(String s, String lng)` Gets local translation of a string from `dictStr`.

**HelpFile.java** Reads help files which are stored in subdirectory `/Help`. Help folder contains filenames like `[Topic]_[3-letter language code].txt`, contents of help file are encoded with UTF-8.

Important attributes:

- helpStr (String) Store string converted from bytes of help file.
- helpNumBytes (String) max length of help file in bytes.

Important methods:

- HelpFile(String screenTitle, String filename) Constructor opens stream to file, reads max helpNumBytes = 2000 bytes, converts bytes to String using UTF-8, puts string into Help textbox.

**SMSsenderForm.java** Sends health record stored in text form through SMS to specific gateway number.

Important attributes:

- pphrMidlet (PPHRmob) Class use this attribute of PPHRmob type to retrieve phone number label, SMS gateway number and message label.
- phoneNumber (String) Store phone number, is equal to SMS gateway number if gateway number is valid.
- smsGatewayNum (String) Default phone number of SMS gateway.
- message (String) Store the message to be sent.
- sendAutomatically (Boolean) Set to TRUE by default which means that message is sent when command Send pressed on cellphone.

Important methods:

- SMSsenderForm(String title, PPHRmob pm) Constructor set phone number, phone label and message label.
- setSendAutomatically(boolean sendAutomatically) Set to indicate whether Send message command invoked when pressed.
- sendSMS() Sends the message based on given non null phone number and port number.

### 3.4 List and Language Management

#### 3.4.1 PPHR\_Lists

PPHR elements are according to ICPC2e coding system and all the elements are stored in a spreadsheet name PPHR\_Lists.xls. The PPHR reads the text file generated from PPHR\_Lists.xls and converts them into lists displaying on cellphone. PPHR\_Lists contains 9 main headers, Count , SN , Element eng , Element deu , Element zho , Element msa , fromSN , toSN and CCR .

Count index number of elements, Element eng deu zho msa are elements name in 4 different languages: eng English, deu Deutsch, zho Chinese, msa Malay.

SN acts as a serial number for each item which equals to index number Count . fromSN and toSN represents the serial number of the next list of an element, e.g. element with SN = 1 has fromSN and toSN 35 and 37 respectively, in the PPHR if element with SN = 1 is selected, element 35 to 37 will be listed on the next list. If any of fromSN and toSN value is -1, it means that it is at the end of list, which will not point to the next list of elements.

CCR contains CCR tag of the corresponding element.

PPHR\_lists.xls is as show in Figure 3-3.

Figure 3-3: ICPC2e Elements Arranged in Spread Sheet for PPHR Usage

1	Count	SN	Element eng	Element deu	Element zho	Element msa	fromSN	toSN										
2	775		eng	deu	zho	msa												
24	21	21	Longitude	Längengrad	经度	Longitud	-1	-1										
25	22	22	Latitude	Breitengrad	纬度	Latitud	-1	-1										
26	23	23	Phone	Telefonnr	电话	No. telefon	-1	-1										
27	24	24	Email	email	电子邮件	Email	-1	-1										
28	25	25	Ethnicity	Ethnische Herkunft	种族	Kaum	-1	-1										
29	26	26	Language	Sprache	语言	Bahasa	-1	-1										
30	27	27	Relation-disease	Familiäre Erkrankungen	关系-疾病	Hubungan-penyakit	-1	-1										
31	28	28	Home life - Family	Familienleben	家庭生活	Kehidupan keluarga	-1	-1										
32	29	29	House environment	Häusumgebung	屋宇环境	Pensekitaran rumah	-1	-1										
33	30	30	Work colleagues	Arbeitskollegen	同事	Rekan kerja	-1	-1										
34	31	31	Work environment	Arbeitsumgebung	工作环境	Pensekitaran kerja	-1	-1										
35	32	32	Education	Ausbildung	教育	Pengajian	-1	-1										
36	33	33	Smoking	Räuchen	吸烟	Merokok	-1	-1										
37	34	34	Alcohol	Alkohol	啤酒	Alkohol	-1	-1										
38	35	35	Condition	Allgemeinzustand	环境	Keadaan	144	146										
39	36	36	Allergy	Allergie	过敏	Alahan	-1	-1										
40	37	37	Blood type	Blutgruppe	血型	Jenis darah	-1	-1										
41	38	38	Overall	Gesamt	总体情况	Kesejahteraan	302	307										
42	39	39	Mental	Psychische Lage	心理	Mental	666	671										
43	40	40	Brain-Nerves	Gehirn - Nerven	大脑-神经	Otak-saraf	147	150										
44	41	41	Head	Kopf	头部	Kepala	151	153										
45	42	42	Eye	Auge	眼睛	Mata	154	156										
46	43	43	Ear	Ohr	耳朵	Telinga	157	159										
47	44	44	Nose	Nase	鼻子	Hidung	154	157										
48	45	44	Mouth-Throat	Mund-Rachen	嘴-喉咙	Mulut-tekak	160	163										
49	46	46	Arm	Arm	手臂	Lengan	168	170										
50	47	47	Hand	Hand	手	Tangan	168	170										
51	48	48	Chest	Brust	胸腔	Dada	171	175										
52	49	49	Breast	Busen	乳房	Buah dada	189	191										
53	50	50	Heart-Circulation	Herz - Kreislauf	心脏-循环	Jantung-pedaran	616	626										
54	51	51	Lungs	Lunge	肺	Paru-paru	629	634										
55	52	52	Back	Rücken	背部	Belakang	176	179										
56	53	53	Abdomen	Bauch	腹部	Abdomen	180	184										
57	54	54	Food-digestion	Ernährung-Verdauung	食物-消化能力	Makanan-penghadaman	635	656										
58	55	55	Kidney-Urine	Nieren - Ham	肾脏-尿液	Organ-air kencing	185	188										
59	56	56	Leg	Bein	腿部	Kaki	168	170										

### ***3.4.1.1 Example Usage of PPHR\_Lists***

Start

1. User selects New Entry on Display
2. Display calls ListMgr for new entry (SN = 0)
3. ListMgr sends list of top-level elements to Display (SN 1-13)
4. Display shows list

UserSelect

1. User selects an element
2. Display sends selection (SN?) to List Mgr
3. ListMgr detects IF SELECTION IS LINKED TO ANOTHER LIST ( fromSN and toSN lists)

If YES, ListMgr sends list from element to element to Display

Else (NO), ListMgr sends no more list to Display"

Display detects IF THERE IS A LIST

If YES, Display shows

- a. The list
- b. And the menu items to go to Next step, or Exit, etc."

Else (NO), Display shows

- a. Frame containing the selected elements with text fields for (optional) user entries
  - b. Current dateTime
3. User enters own comments and values in the text field for each parameter if he wants [Optional - not implemented]: User edits dateTime
  4. User selects Save new entry from the Menu
  5. Display sends chain of elements + value + dateTime + language code + se flags to Record Manager for storage. s/S flag - not sent or Sent via SMS to backup. e/E flag - not an error or entry flagged as Error.

### ***3.4.1.2 Convert PPHR\_Lists.xls to PPHR\_Lists.txt***

To create the PPHR\_Lists.txt file for the PPHR, select the OneList sheet:

- Temporarily delete the first column (A or Count)
- Temporarily delete the top row (1 or SN)
- Save as the rest as Unicode Text (\*.txt) with an appropriate file name e.g. PPHR\_Lists\_[date]\_Unicode.txt

Problem:

MS Excel automatically saves .csv files with the ANSI character set, so non-ANSI characters such as Chinese appear as garbage. To preserve these characters we must save .csv files with Unicode or UTF-8 encoding. MS Excel offers a Unicode option.

Solution:

- Save OneList as PPHR\_Lists\_[date]\_Unicode.txt as described above. This creates a tab-delimited Unicode txt file.
- "Open this Unicode file in MS Word and replace all the tabs with commas (,), delete all rows after the end of the PPHR entries (sometimes there are many rows of commas after the real end), delete any quotation marks (""), and save the result, still with Unicode encoding. There should be only one end of line character on the last line of the file."
- "Open this Unicode file in Notepad or other Unicode-and-UTF8-enabled text editor, then Save as and choose UTF-8 encoding and give another filename e.g. PPHR\_Lists\_[date]\_UTF8.txt."
- Copy the PPHR\_Lists\_[date]\_UTF8.txt file to the J2ME project /src directory and rename it to PPHR\_Lists.txt.
- The UTF8 txt file may start with some non-alphanumeric characters which remain in PPHR\_Lists.txt. The PPHR program removes these before it reads the rest of the content.

### 3.4.2 Cellphone Commands Languages

The PPHR is available in four different languages, English, Deutsch, Chinese and Malay, commands of the PPHR shall be presented in the chosen language too. CommandDict.txt contains all the user interface text including messages in all the available languages. It lists the available languages in 3-letter ISO639-3 Languages Codes as a single word with no spaces. All the commands and messages are listed with language translations in the same order as the list of languages except GO command on the first screen of language selection. Every command created by the PPHR, the PPHR first obtains the language chosen to run the PPHR, and then read CommandDict.txt for the translation of command name according to chosen language. Examples of CommandDict.txt content:

Languages English Deutsch 中文 Bahasa\_MY

LanguageCodes eng deu zho msa

cmd=expandCmd eng="Expand" deu="Vergrößern" zho="扩展" msa="Kembang"

cmd=searchCmd eng="Search" deu="Suchen" zho="搜索" msa="Cari"

cmd=lblFromTo eng="From-To" deu="Von-Bis" zho="從-到" msa="Dari-Sehingga"

### **3.5 PPHR User Interface and Software Functionality**

As discussed in above sections, usability is important for inputting complicated data and to display or navigate through data on a small-screen device like a cellphone. The user interface is very important to achieve this. In order to maximize efficiency of the PPHR on a cellphone, the PPHR is available in different languages; images are used to replace long lists of text; image-based selection technique works for J2ME-enabled cellphones, and the user can freely insert additional information which is not available by default.

#### **3.5.1 Starting Screen with Mode and Languages**

The sequence diagram below illustrates the interactions between classes in PPHR when PPHR user is on the starting screen initiating commands to start and selecting from demographic list.

Sequence Diagram- 1: Starting Screen and Demographic Entries

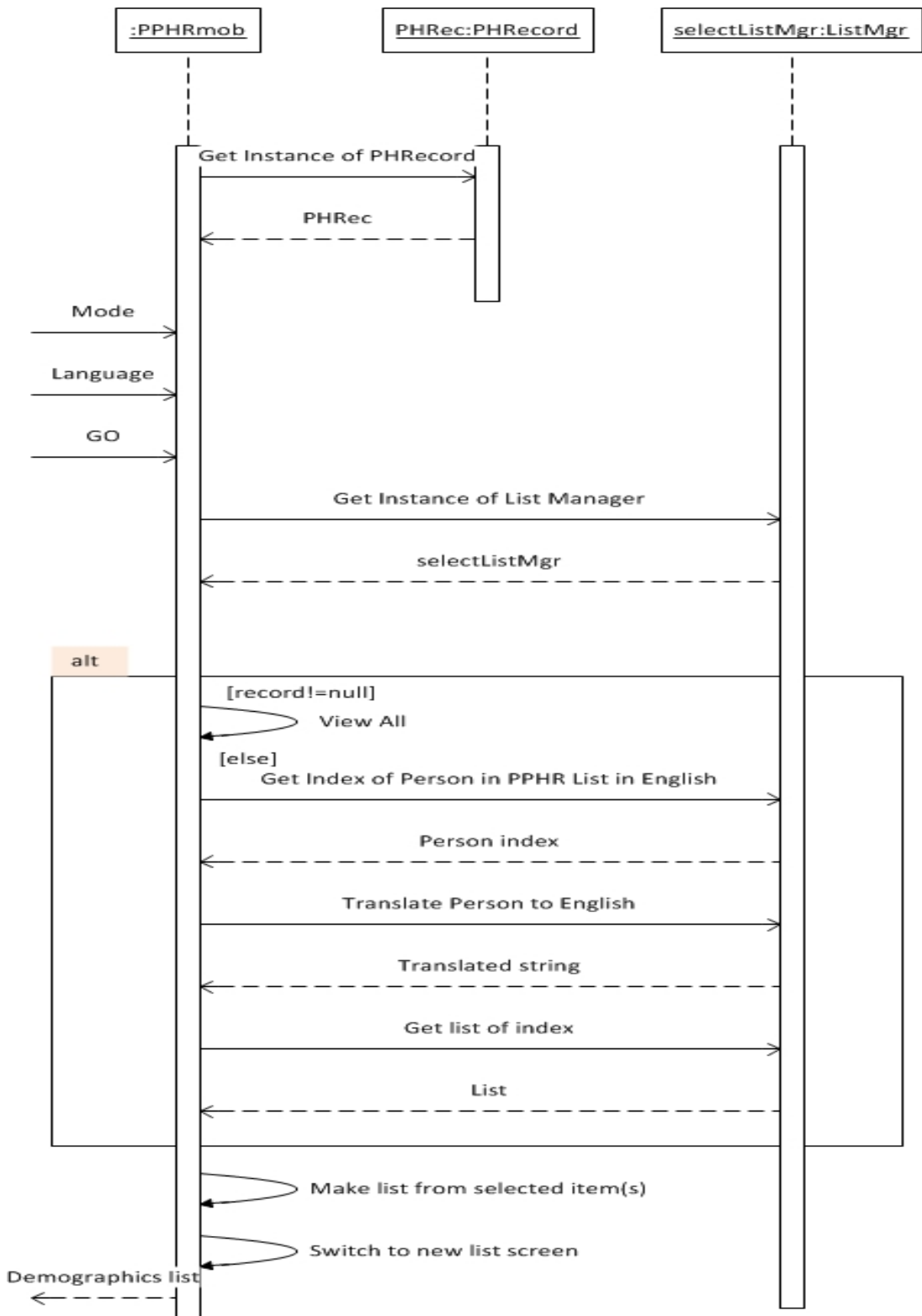


Figure 3-4 is the starting screen of PPHR; Users first select either text mode or GUI mode of PPHR. GUI mode includes anatomy image of body parts and health record



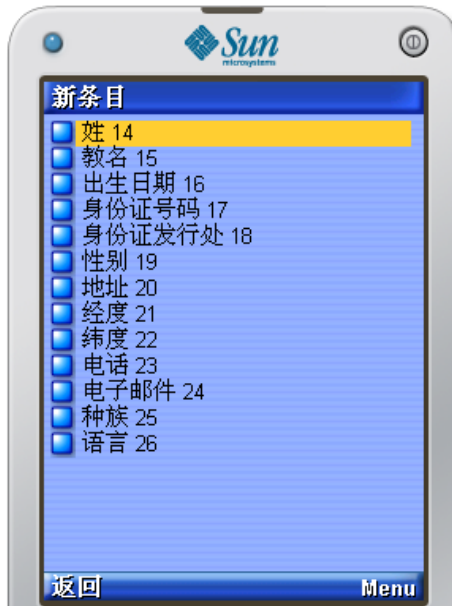
visualization. Users then select a language - English, Deutsch, Chinese, Malay as shown in Figure 3-4A. Select GO on the bottom left of the screen to proceed to next step, which shows a list of personal profile entries to be inserted into the record as shown in Figure 3-4B, C, D, E. Details about interactions between classes of PPHR are illustrated in Sequence Diagram- 1 showed above. If the PPHR record is not empty, the PPHR will get the PPHR list, and then get person index to display translated demographic list. If the PPHR record is not empty, then the PPHR will display all record in view screen instead of showing demographic list to be selected. Users are allowed to select one or more selection boxes to enter more than one detail at once, see Figure 3-4.

**Figure 3-4: Start Screen**

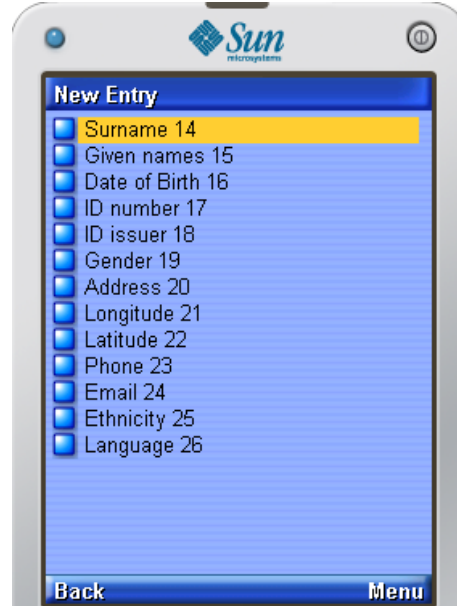
**3-4A: Text-Graphics Choice and Language Selection**



3-4B: Demographics List in Chinese



3-4C: Demographics List in English



3-4D: Demographics List in Deutsch



3-4E: Demographics List in Malay



## 3-4F: Go to Next Step of Demographics List



The selection boxes support multiple selections; select Menu -> Next step to go to the next page of form. Surname, given names and date of birth are compulsory detail to be included. In Figure 3-5A, after the user inputs personal details in the lines under each item, the user needs to save the entry manually as shown in Figure 3-5B. Figure 3-5C shows a screen with the text fields background colour in grey which means that the entries have been saved. The Menu on this page of display consists of Save New Entry, Make New Entry, and View All main functions. Help and Exit are available on every page. After saving personal details entries, users can make a new entry by selecting Make New Entry in the Menu, as shown in Figure 3-5D.

**Figure 3-5: Demographic Input Screen**  
3-5A: Enter Selected Personal Detail



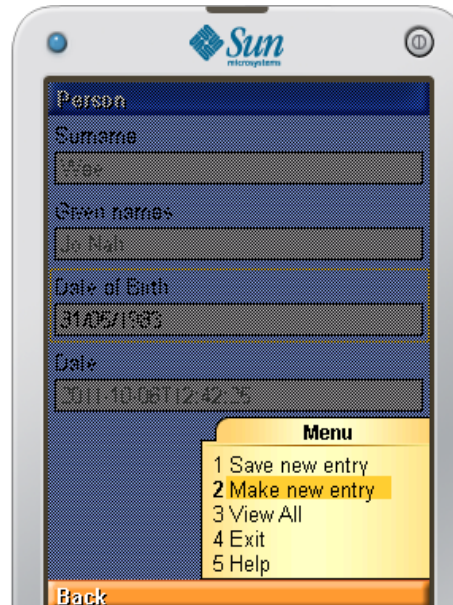
3-5B: Choose to Save Entries



3-5C: Entries Saved



3-5D: Make New Entry

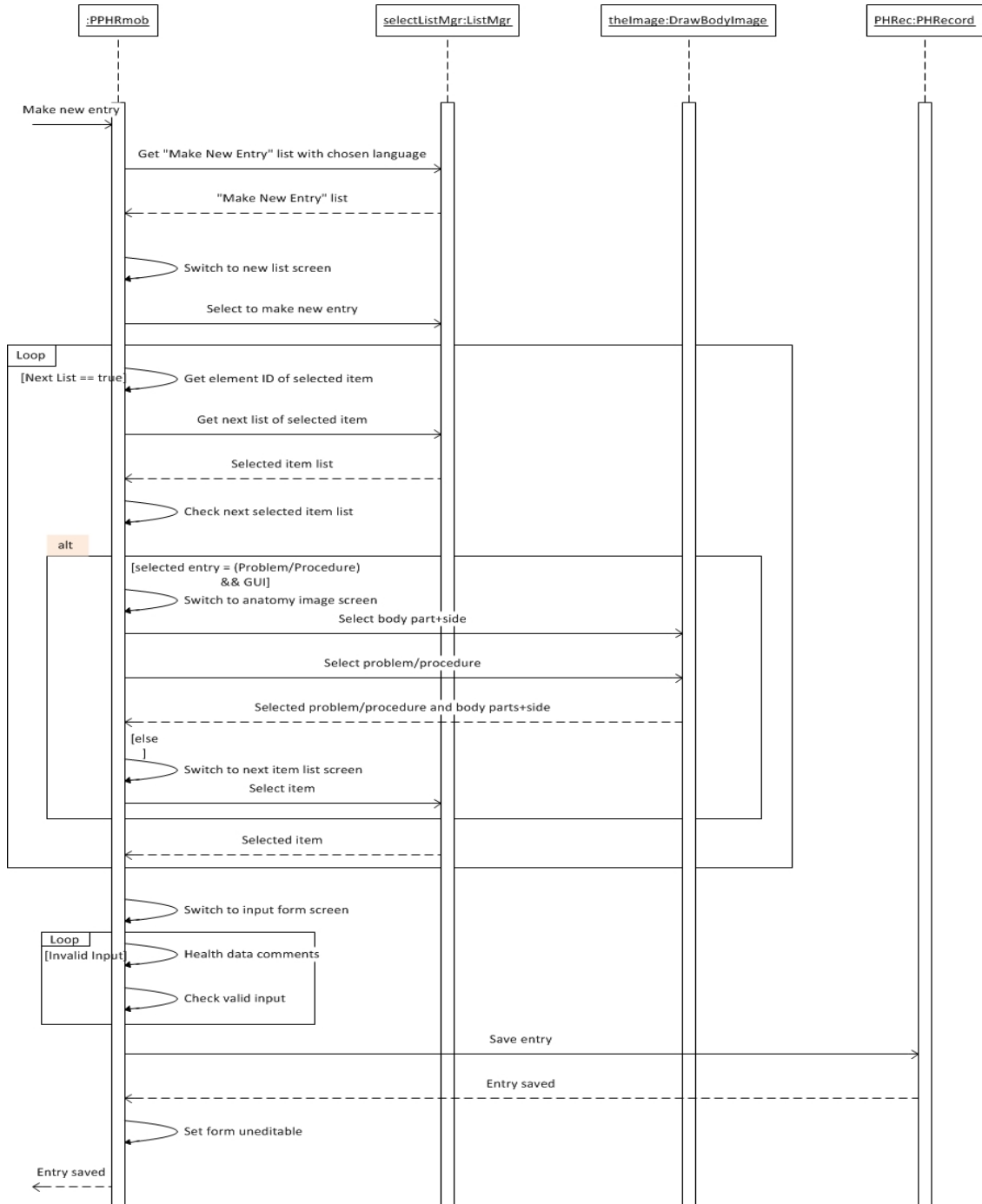


### 3.5.2 Select “Make New Entry”

Sequence Diagram- 2 shows the interactions between ListMgr, DrawBodyImage, PHRecord and PPHRmob (midlet) classes. PPHRmob only interact with DrawBodyImage if GUI mode is used and Problem or Procedure is selected. PPHRmob interact with ListMgr the most as ListMgr do most of the listing while Make

new entry has a lot of listings involved. PHRecord class will only involve when there are entries to be saved.

**Sequence Diagram- 2: Make New Entry**



If Make new entry is selected, a new page will be directed straight away, which consists of a list of entries categorised by coding system used, ICPC2e. All the information related to health are included to next list, information includes Alert,

Problem, Body signs, Results, Medication, Procedure, Diagnosis, Notes, Vaccination, Person, Social-history, Family-history and Medical devices. Refer Figure 3-6 for above statement.

### ***3.5.2.1 Selecting Problem or Procedure in New Entry***

In Text Mode, selecting Problem (or Procedure) will lead to a sequence as described above for choosing the anatomical location; refer to Figure 3-6D. In Graphics Mode images are used. Selecting Problem or Procedure lead to the same page, an anatomical image will be displayed and users are able to select different body parts, see Figure 3-6C. Refer to Figure 3-6A, B for screenshot of above statements. Although both lead to an anatomical image, but the input entries after selecting body parts and organs will be different as Problem and Procedure both have different elements of entries, see Figure 3-6F,G.

**Figure 3-6: Processing Problem/Procedure**

3-6A: Select Problem to Make

New Problem Entry

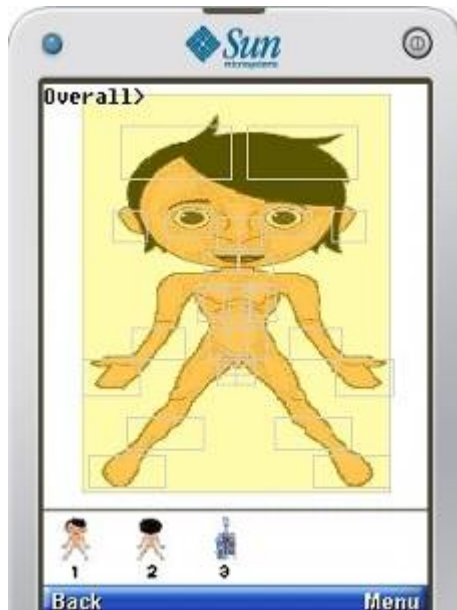


3-6B: Select Procedure to Make

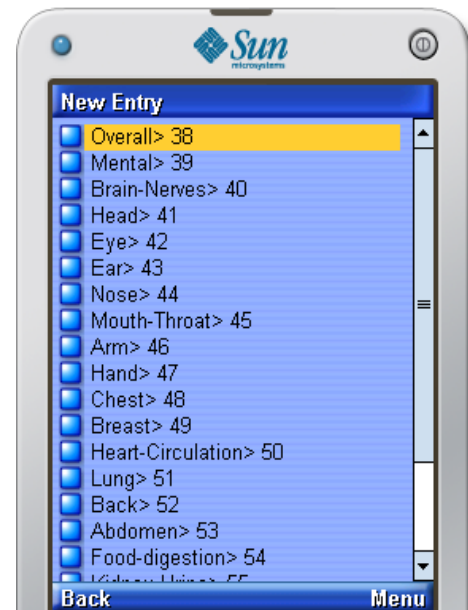
New Procedure Entry



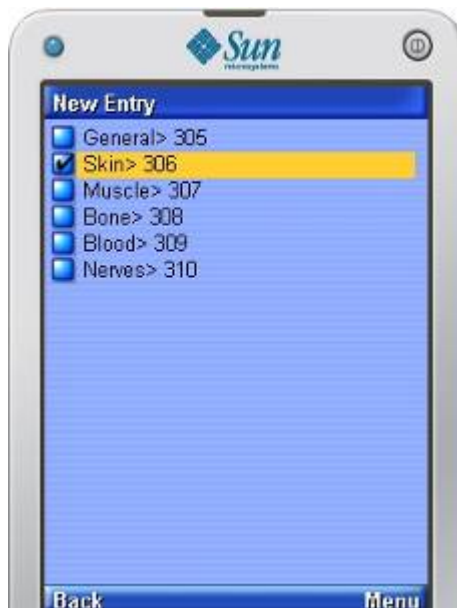
3-6C: Body Part Illustrated Graphically  
(Graphic Mode)



3-6D: Body Part Illustrated in Text  
(Text Mode)



3-6E: Next List of Overall Body Part



In Figure 3-6C and Figure 3-6D, the whole body is selected, as indicated by the location Overall in the upper left corner. User can switch to rear view or internal view by pressing keypad 1, 2 or 3. Region filled with yellow colour indicates that region has been selected. Figure 3-6E shows that after selection of Menu -> Next Step a new page appears with a list of tissues of selected body part, such as skin, muscle,

bone, blood, and nerves. Skin is selected, then following the selection Menu -> Next Step the next screen appears (Figure 3-6F, Figure 3-6G).

3-6F: Problem List for Overall Location

3-6G: Procedure List for Overall Location



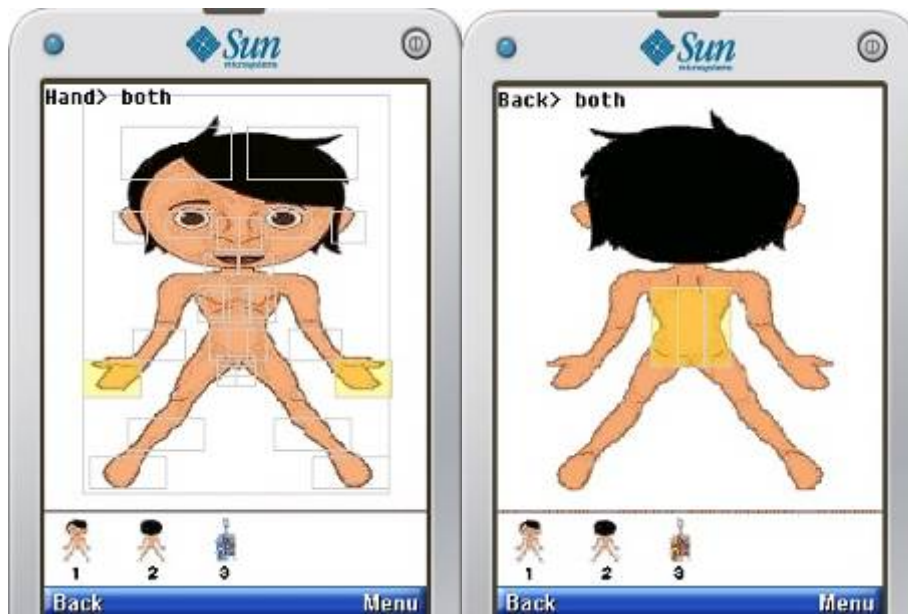
As shown above, Problem and Procedure will lead to a different list after selections of body parts and organs but anatomy image and available selection of body parts are exactly the same, PPHR will lead the next list accordingly to Problem or Procedure.

### ***3.5.2.2 Views and Body Parts Switching***

Views of anatomy image can be switched by pressing keypad 1, 2, and 3. 1 is for front view, which is a default view, 2 is for rear view and 3 is for internal view. Front/Rear/Internal Views in PPHR are shown in Figure 3-7.

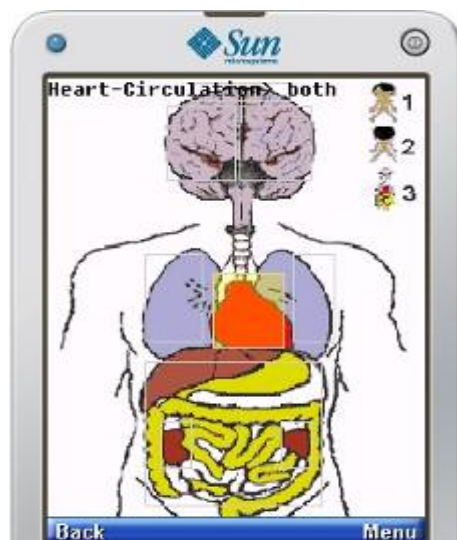


Figure 3-7: Front/Rear/Internal Views



Front View

Rear View



Internal View

The grey line boxes on the anatomy image indicate regions which are selectable. If a region is selected, it will be highlighted with yellow colour. In the internal view shown above, Heart-Circulation has been selected, and as there is only one heart, the side is given as both. Arrow keys UP and DOWN are used to switch body parts, and keys LEFT and RIGHT are used to indicate sides of body part.

### ***3.5.2.3 Insert Data and Comments***

In Figure 3-8, problems selected preview are displayed in form style before saving the entries. If users have extra information to include which are not in the list provided,

there are text-boxes provided for each entry to add in data and comments, e.g. Insect bite-sting text field and input Mosquito or Bee to specify which insect bit.

**Figure 3-8: Input and View Records**

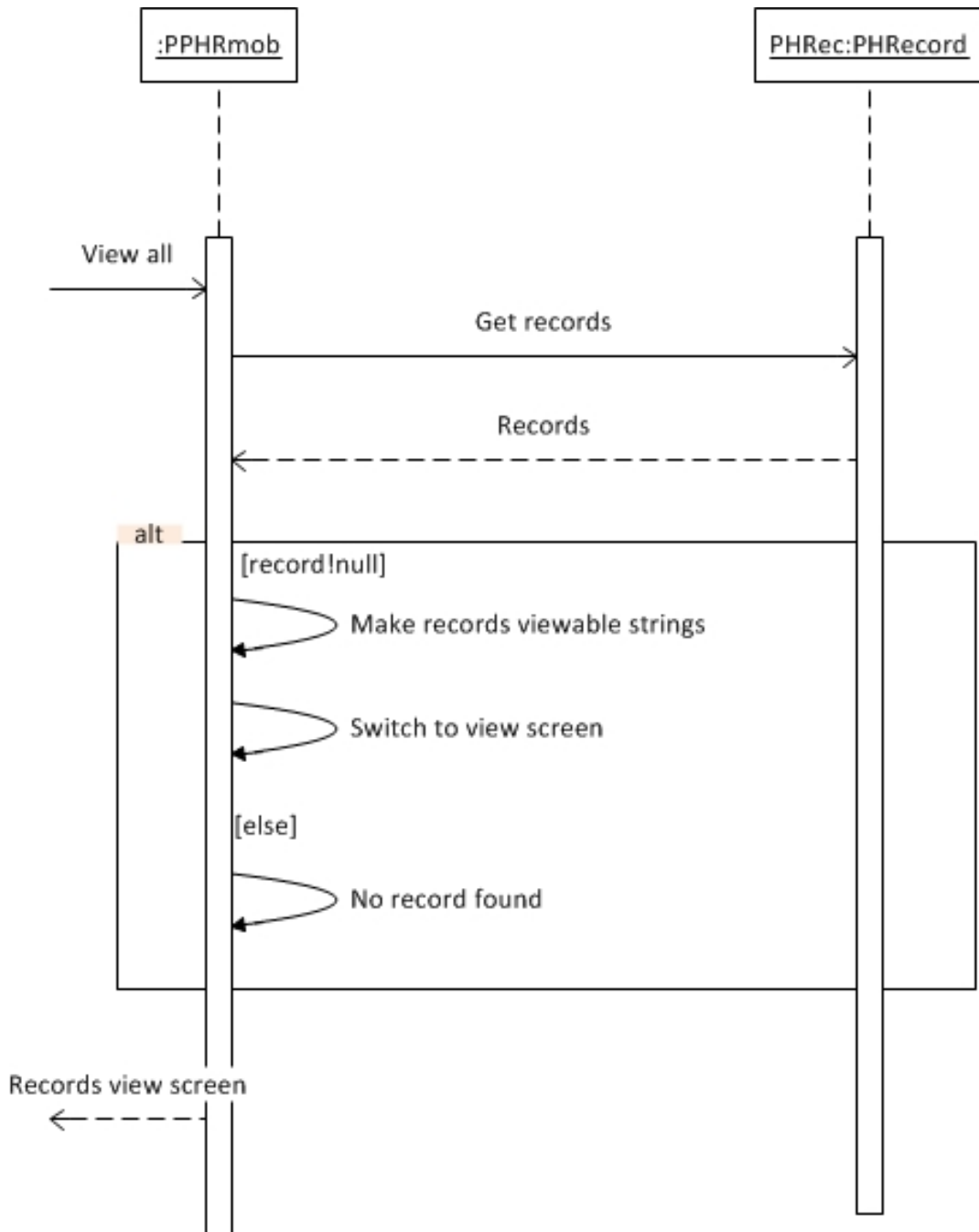


The screenshot displays a mobile application interface with a blue header bar containing the 'Sun' logo. The navigation path 'Problem > Hand > both > Skin' is shown in a blue bar. Below this, there are several text input fields for 'Pain-tenderness', 'Itching', 'Local swelling', 'Insect bite-sting', and 'Foreign body'. A 'Date' field is also present, showing '2011-02-25T09:26:13'. A 'Qwerty' keyboard indicator is visible next to the 'Itching' field. At the bottom, there are 'Back' and 'Menu' buttons.

### 3.5.3 View All

To view all, PPHRmob is only required to interact with PHRecord. PPHRmob get records from PHRecord, if the record is unavailable or empty, PPHRmob will state that no record is found. Otherwise, PPHRmob will make records viewable strings and display the records on view screen, see Sequence Diagram- 3 for above statement.

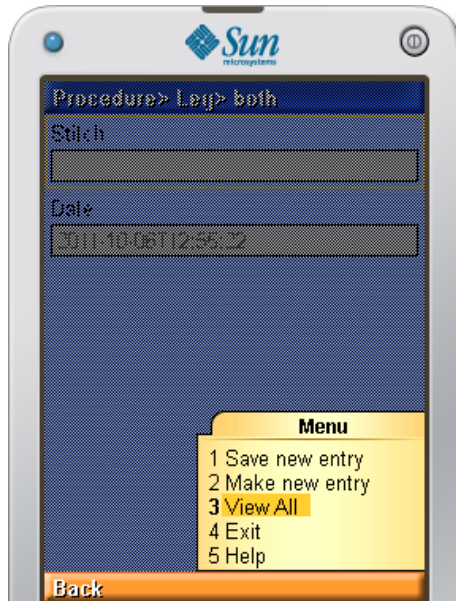
Sequence Diagram- 3: View All



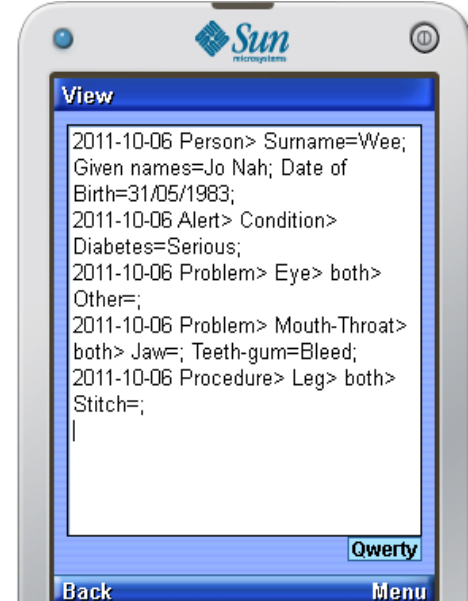
In Figure 3-9A, user select `View All` after saving a procedure entry. `View All` can be initiated from the `Menu` in every screen of entering entry, the screen will shows all records stored in text form, see Figure 3-9B.

**Figure 3-9: View all records**

3-9A: View All after Save Entry



3-9B: All Records are displayed



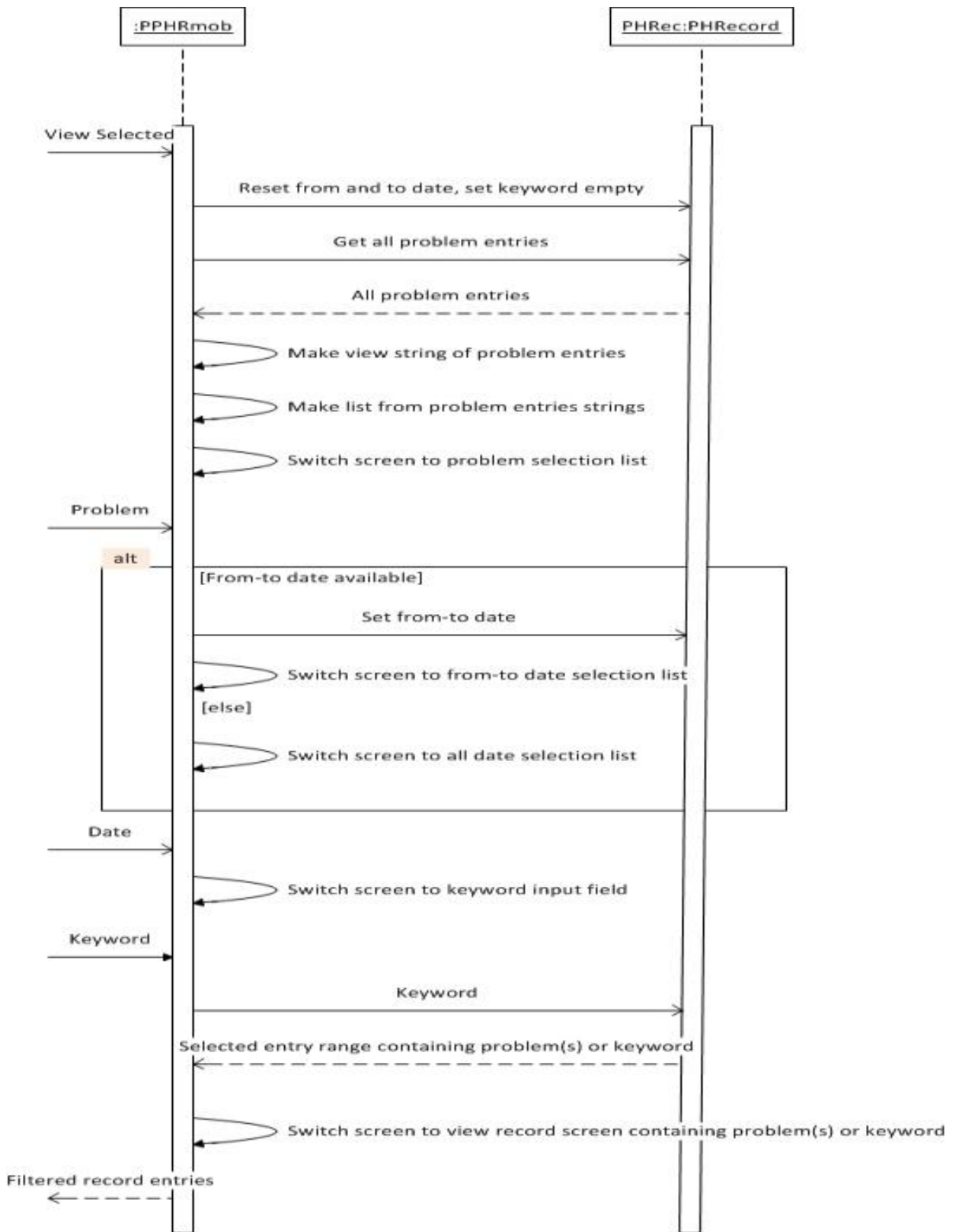
### 3.5.4 View Selected

View Selected has different interface in text and GUI mode. The main usage of View Selected is to navigate certain record or type of record from large chunk of data. Records can be navigated by date, type of record or by searching with keywords. View Selected can be initiated from the Menu in view record screen.

#### 3.5.4.1 Text Mode View Selected

Sequence Diagram- 4 shows the sequence of interactions between PPHRmob and PHRecord classes. The first screen displayed to user when View Selected is selected in text mode, is a list of problem entries. PHRecord check whether user selected a range of date, if the user selected from a range of date of problem entries, PPHRmob displays a list of dates with user selected dates range, otherwise display all dates. Keyword entered will be stored in PHRecord and PHRecord will also send the filtered records back to the PPHRmob in order to display on screen.

Sequence Diagram- 4: View Selected (Text Mode)



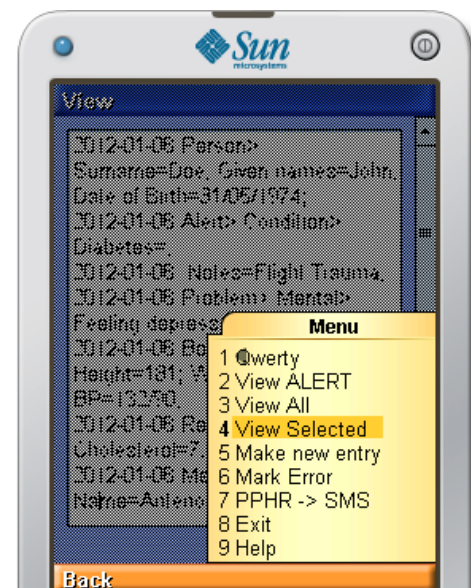
View Selected is initiated in the record viewing screen. In text mode, problem entries are listed on the first screen, see Figure 3-10A. In the menu of view record screen, select View Selected as shown in Figure 3-10B to go to problem selecting screen. In problem selecting screen in Figure 3-10C, users are allowed to select one or more problems or all problems. Figure 3-10E shows the next screen after selecting problem entries, a list of dates of entries inserted will be listed, including a choice for all dates. One entry can be selected among the dates listed to indicate the records which will be searched from the selected date to the last date. If multiple entries are selected, it indicates that PPHR will navigate the record from the earliest selected date to the latest selected date. If All Dates is selected, means records will be navigated from all dates, which is the same with selecting the first date only, or selecting the first and the last date entries. The reason of implementing date selection screen is to enable navigation of certain records within a range of dates.

**Figure 3-10: View Selected (Text Mode)**

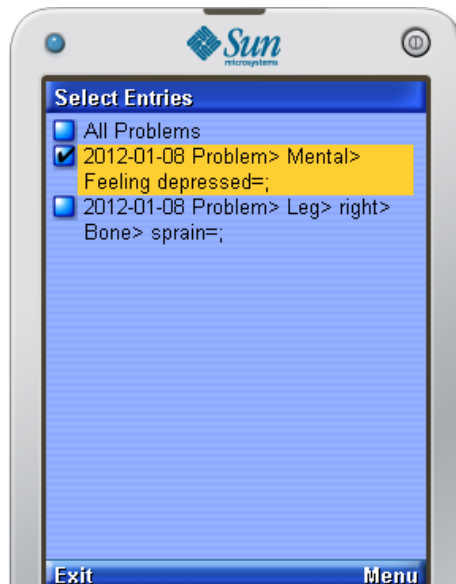
3-10A: All Records



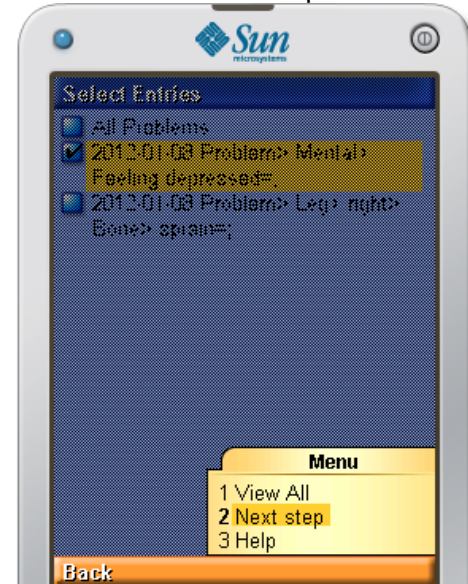
3-10B: Select View Selected



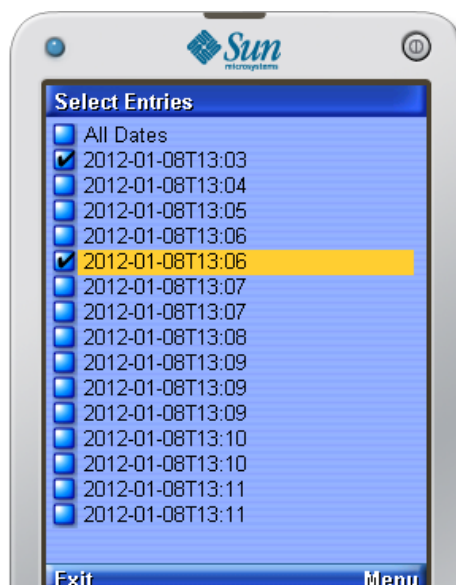
3-10C: Select a Problem



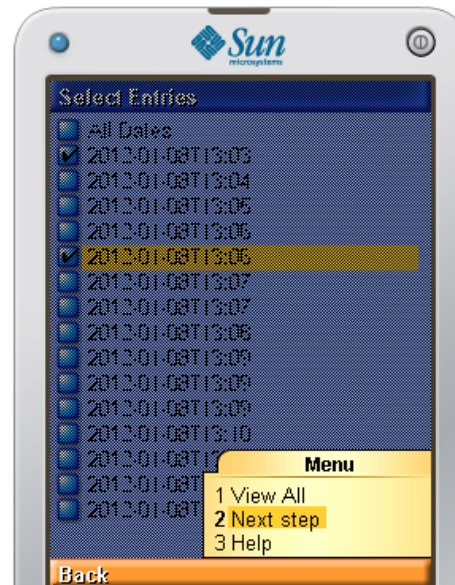
3-10D: Go to Next Step



3-10E: Select From-To Dates



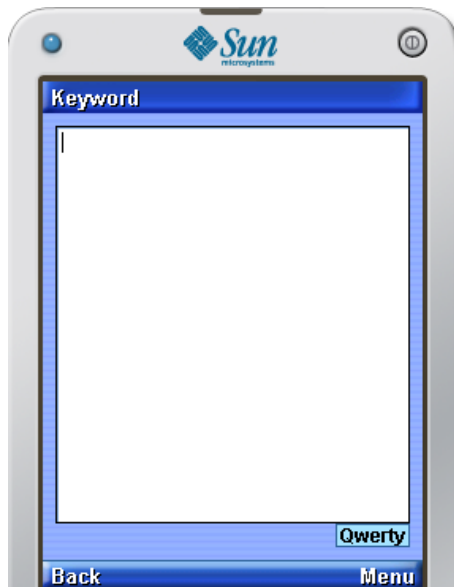
3-10F: Go To Next Step



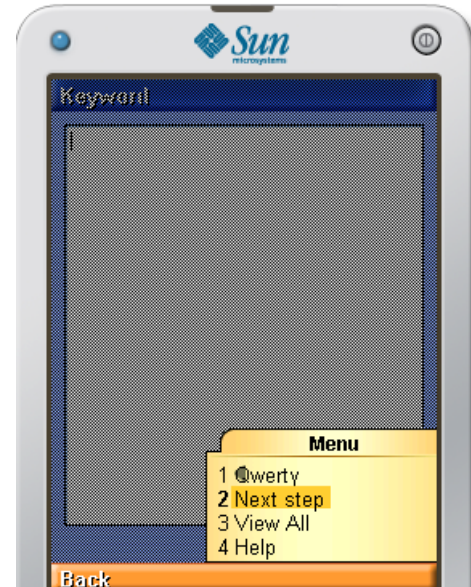
After selecting dates, go to Next step in Menu . In Figure 3-10G a keyword field screen is displayed and the users can key in any keyword related to the record they want to search. If keyword field is left blank, then record navigation will not be filtered with keyword. As shown in Figure 3-10C and Figure 3-10E, a problem entry 2012-01-08 Problem>Mental>Feeling depressed=; , the dates selected are 2012-01-08T13:03 and 2012-01-08T13:06 , since there is no keyword given in Figure 3-10G, it means that the record will be showing on screen later display the record for problem 2012-01-08 Problem>Mental>Feeling depressed=; , and all the other records from 2012-01-

08T13:03 to 2012-01-08T13:06, see Figure 3-10I. Sequence Diagram- 4 illustrates how PPHRmob class interact with PHRecord class in View Selected (Text Mode) .

3-10G: No Keyword



3-10H: Go to Next Step



3-10I: Record from Selected Date Ranges.

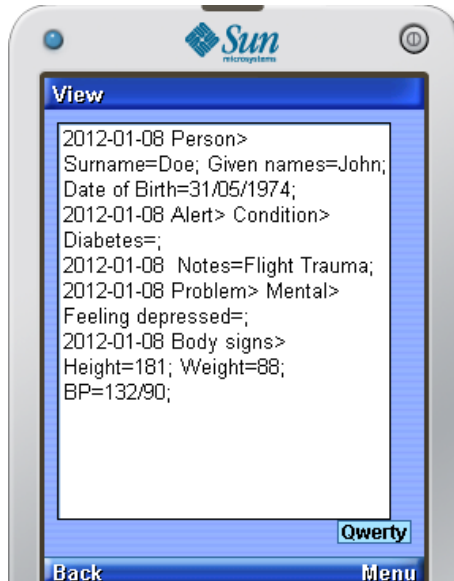
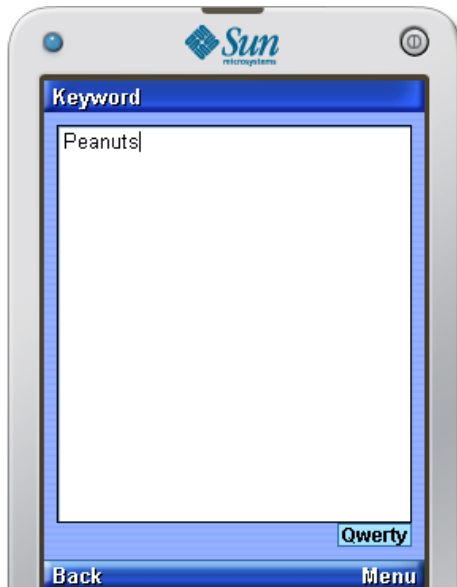


Figure 3-10J shows a case which keyword field is not empty but with a string Peanuts , then only record with string within the dates range selected will take into count. After keying in Peanuts and going to next step, the view screen shows nothing because there are no records containing the keyword Peanuts in the selected dates range (See Figure 3-10L). Figure 3-10M shows a keyword field with another keyword Flight ,



the selected dates range contains a record 2012-01-08 Notes=Flight Trauma; (refer Figure 3-10I). In this case, the next screen of entering keyword will display a view screen with the record containing keyword Flight , see Figure 3-10O.

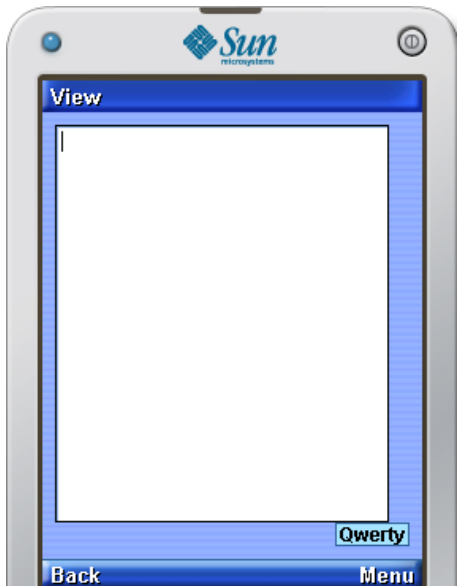
3-10J: With Keyword Peanuts



3-10K: Go to Next Step



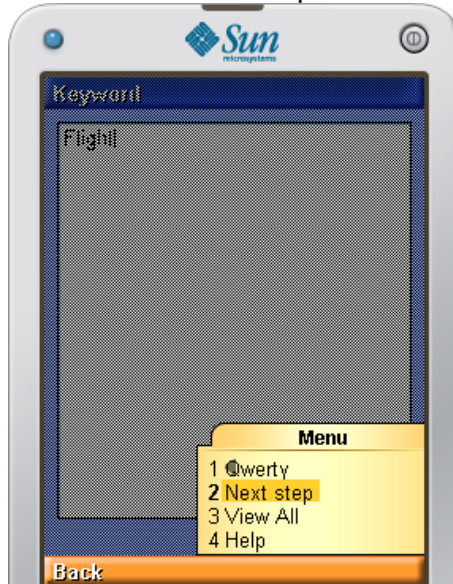
3-10L: No Record with Keyword



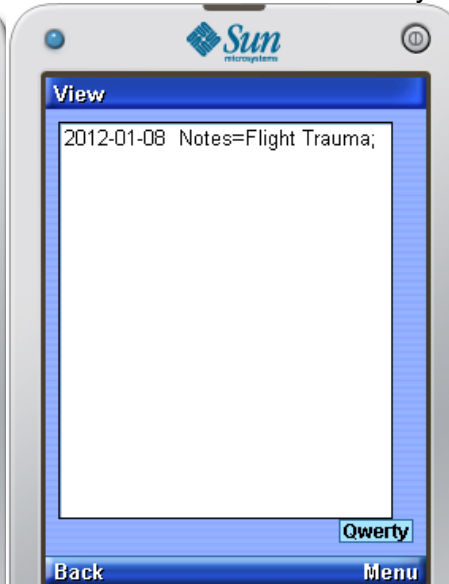
3-10M: With Keyword Flight



3-10N: Go to Next Step

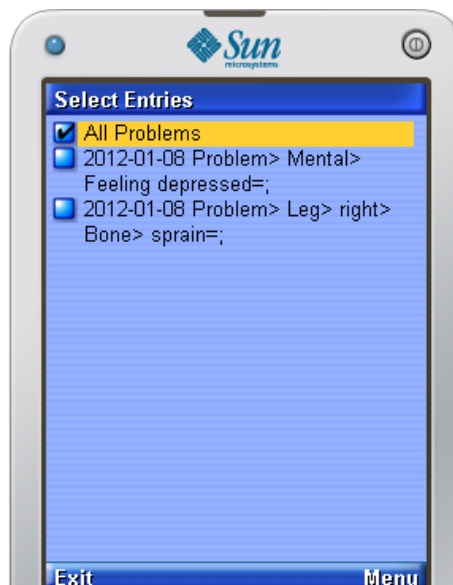


3-10O: Show Record with Keyword

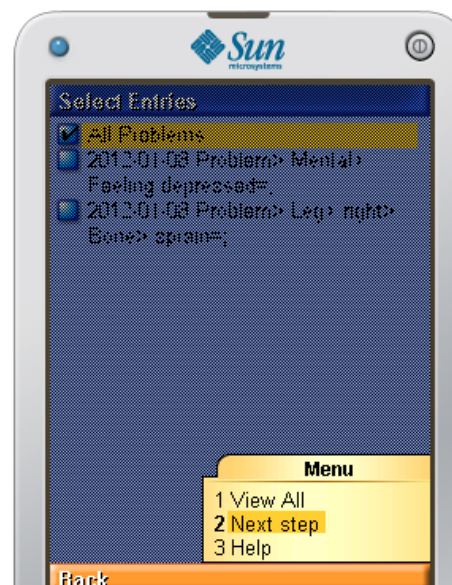


To search for specific problems only, for example a user is searching for problem related to sprain, the user can selected All Problems in problem selection screen, select All Dates in date selection screen, then key in sprain in keyword screen, go to the final step, and the problem entry with the keyword sprain will be displayed on view record screen, see Figure 3-10P, 3-10R, 3-10T, and 3-10V.

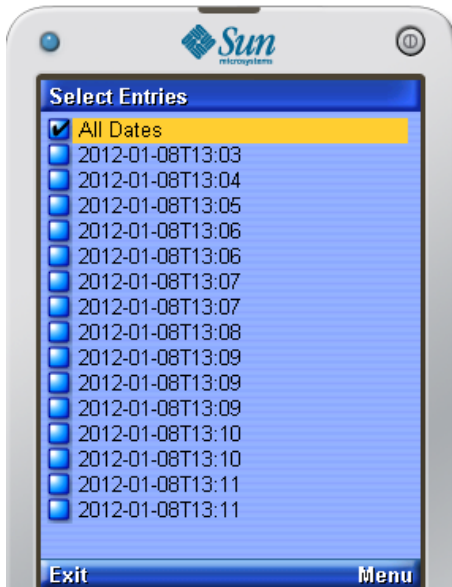
3-10P: Select All Problems



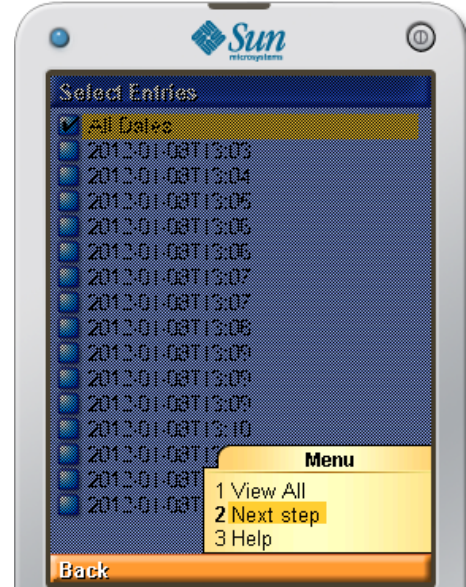
3-10Q: Go to Next Step



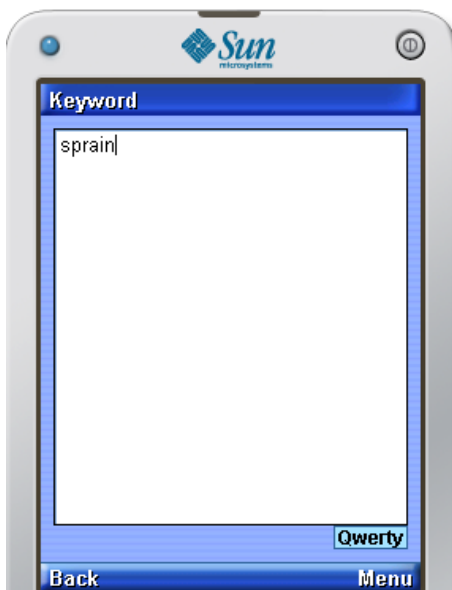
3-10R: Select All Dates



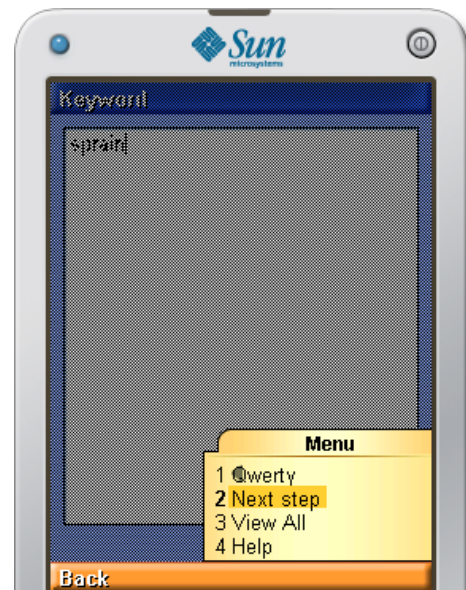
3-10S: Go to Next Step



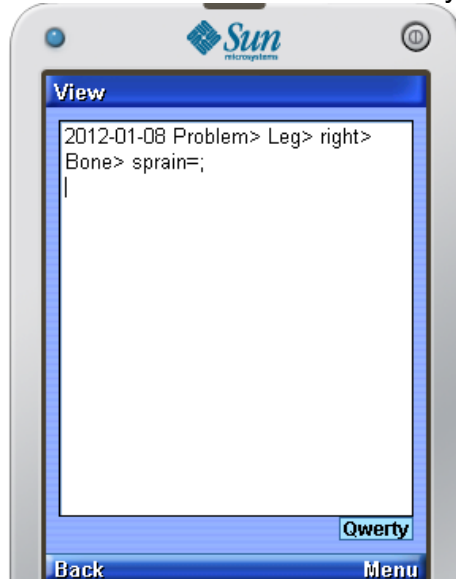
3-10T: Keyword sprain



3-10U: Go to Next Step



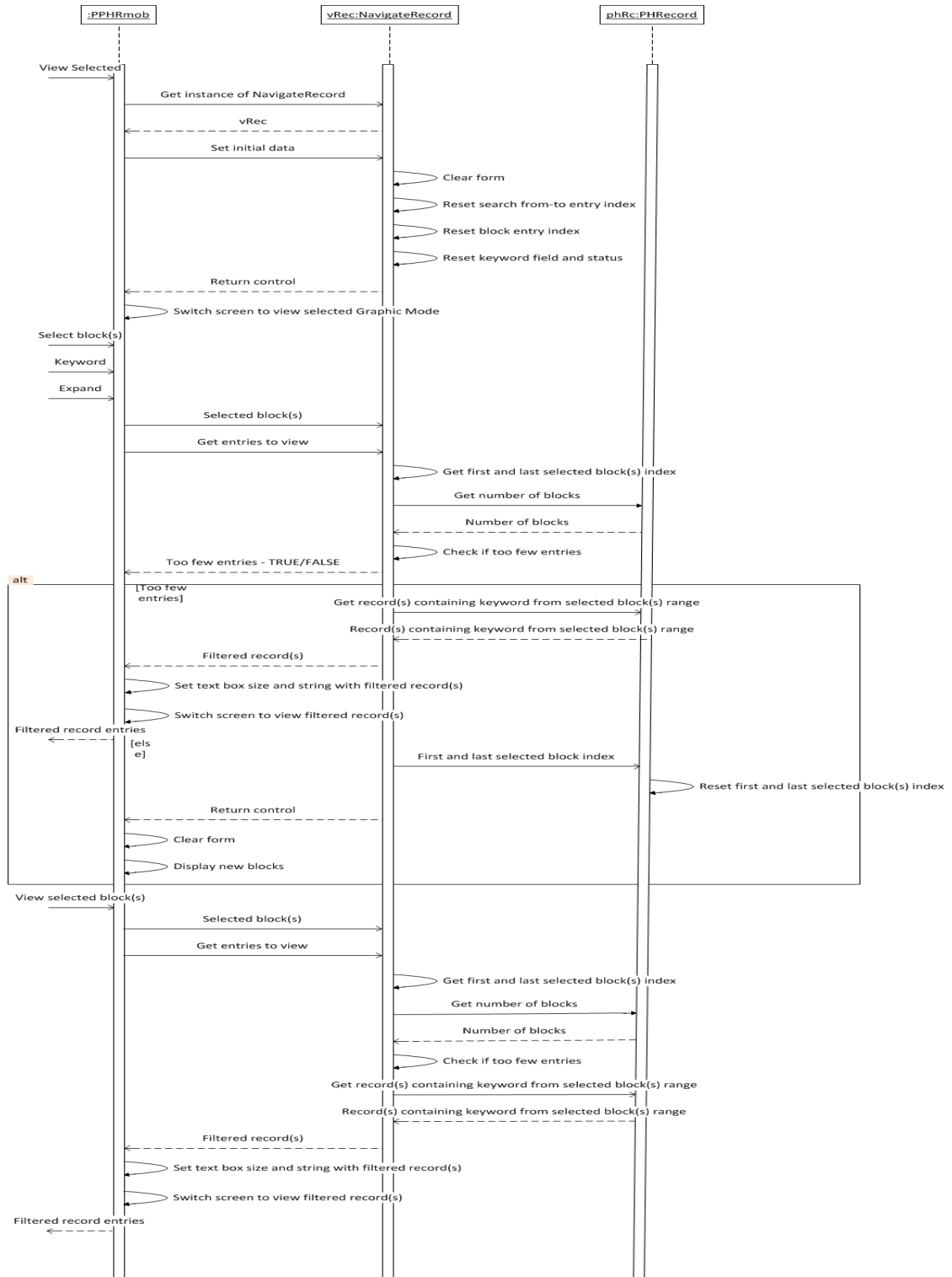
3-10V: Find All Problems With Keyword sprain



#### ***3.5.4.2 View Selected in Graphic Mode***

There are two commands for managing records navigation, expand and view selected. Sequence Diagram- 5 shows the interactions between PPHRmob, NavigateRecord and PHRecord when doing View Selected (Graphic Mode) . Each time of View Selected (Graphic Mode) is initiated NavigateRecord class has to reset initial data so that the displaying form screen will not display data from last navigation. Initial data to be reset include from-To entry index, block entry index, keyword field and status. After the expand method is initiated, the NavigateRecord gets the first and last selected entries index then compare to the number of blocks set in PHRecord class. If the number of entries between the first and last selected entries are too few to be displayed in blocks, then instead of expand, PPHRmob will display records from the first and last selected entries. If the entries are many enough to be displayed in blocks, then PHRecord reset the first and last entries index and the PPHRmob will display new set of blocks. Similar sequence to view selected except NavigateRecord does not have to organize entries into blocks, PPHRmob will directly display the records from the first and last selected entries.

Sequence Diagram- 5: View Selected (Graphic Mode)



In PPHR graphic mode, the view select interface is much simpler. Keyword field, dates list, and entries type are all presented on one screen (see Figure 3-11A). The entries are grouped into blocks, and each block contains entries in a range of dates. A fixed

number of five blocks was chosen to fit on smaller cellphone screens; thus the entries to be selected or viewed are grouped into five blocks. Colour codes are used to indicate the types of entries contained in each block. The colour code is:

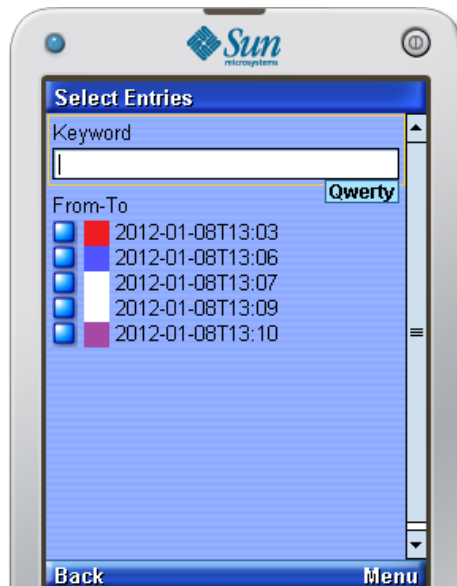
- white does not contain Alert, Problem, or a keyword
- red contains Alert entry
- blue contains Problem entry
- green contains a keyword
- purple (= red + blue) contains Alert and Problem entries
- yellow (= red + green) contains Alert entry and a keyword
- blue-green (= blue + green) contains Problem entry and a keyword
- gray (= red + blue + green) contains an Alert entry, a Problem entry and a keyword

In Figure 3-11 the first block with a red square box tells the user that the block of records starting at the given date and going up to the next block date contains at least one Alert entry, it is also an alternative way to identify alert besides the View Alert command which can be made on any view record screen. Second block with blue square box means the records from the labelled date to the next labelled block's date consist of at least one problem entry and last purple colour block indicates that there are both alert and problem entries in that date ranges. White colour block is for records which do not consist of alert, problem or keyword. The date's list in graphic mode is much shorter as the dates are divided into blocks.

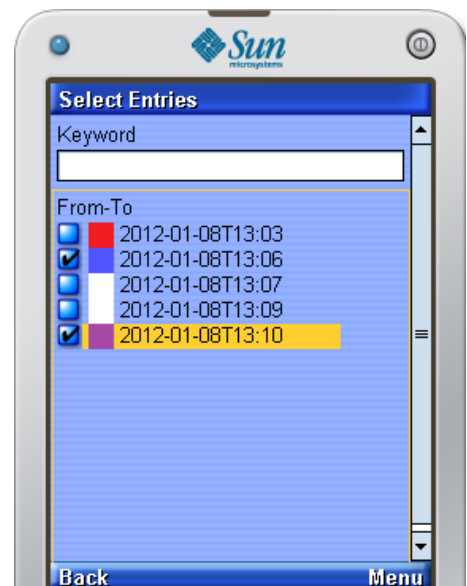
In Figure 3-11B, two blocks are selected, 2012-01-08T13:06 with blue label and 2012-01-08T13:10 with purple label. Without including any keyword and select View Selected from the Menu as shown in Figure 3-11C, the PPHR will display all the records from date 2012-01-08 time 13:06 to date 2012-01-08 time 13:10 on view screen (see Figure 3-11D). If Expand in the Menu is selected instead of View Selected, the PPHR will expand the selected range of blocks and display those (four selected blocks) on screen as five blocks starting from date 2012-01-08 time 13:06 and ending with date 2012-01-08 time 13:10. This is to exclude the first block of dates 2012-01-08T13:03 on the list, so the PPHR will rearrange the dates from date 2012-01-08 time 13:06 to date 2012-01-08 time 13:10 into blocks and display it on screen as shown in Figure 3-11E and 3-11F.

**Figure 3-11: View Selected (Graphic Mode)**

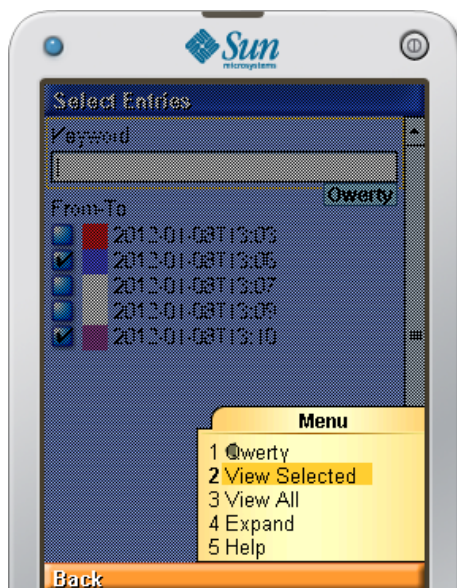
3-11A: First Screen of GUI View Selected



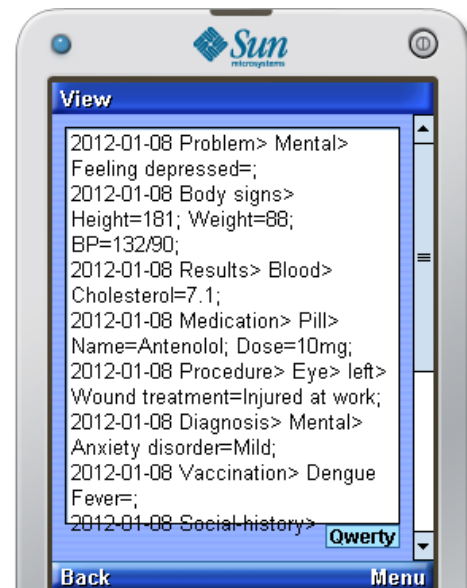
3-11B: Select a Date Range



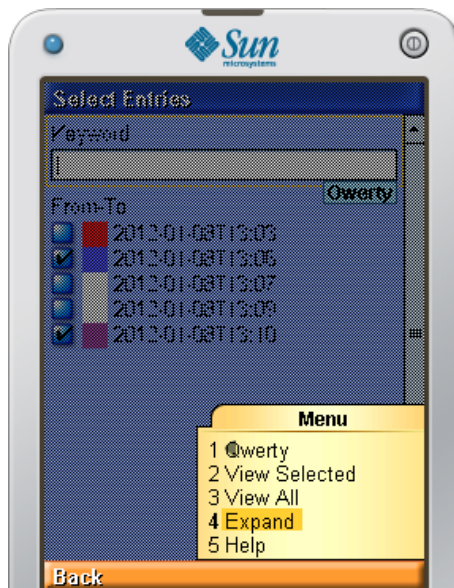
3-11C: Choose View Selected



3-11D: Display Records From Date Range



3-11E: Choose Expand



3-11F: Entries Expanded

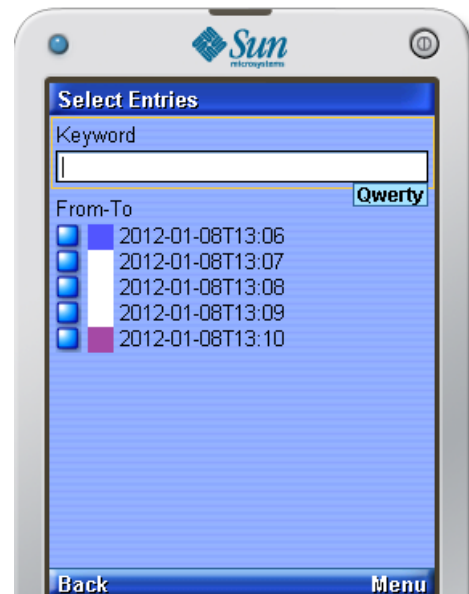
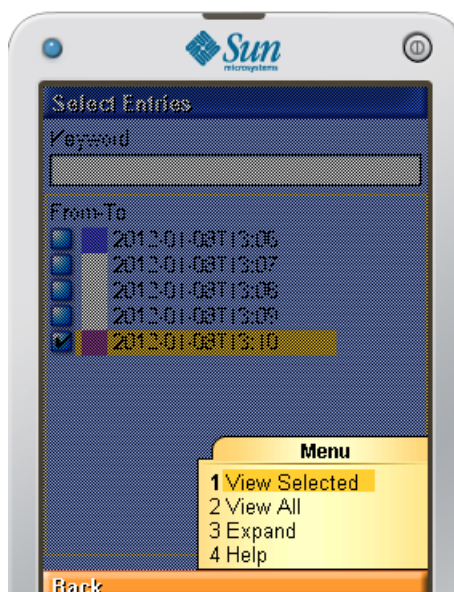
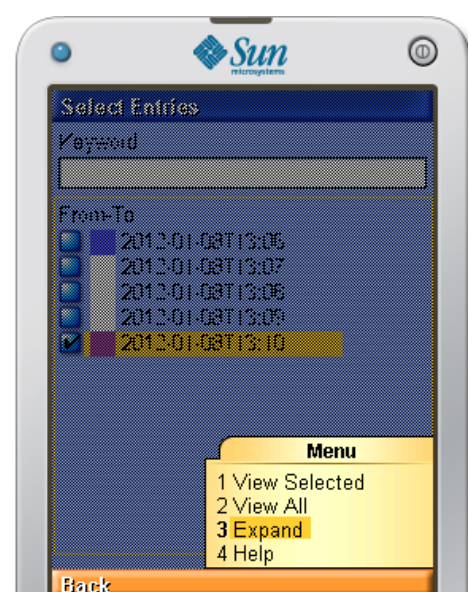


Figure 3-11F shows an expanded list of blocks from 2012-01-08T13:06 to 2012-01-08T13:10 with the block labelled 2012-01-08T13:10 selected. The View Selected and Expand actions are made on the same block, and PPHR will display all records with dates included in the selected blocks, see Figure 3-11G, 3-11H, 3-11I. Expand is designed to display list of entry blocks labelled with dates if the selected block or blocks to be expanded consist of more than five record entries to be displayed in the next list. If the selected block has less than five record entries, then the result of Expand will directly display the records on view screen instead of make them into blocks.

3-11G: View Selected on One Block



3-11H: Expand on One Block





## 3-11I: Result of View Selected and Expand

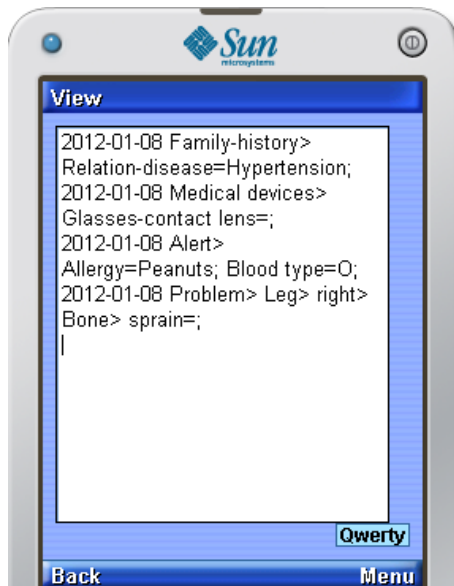
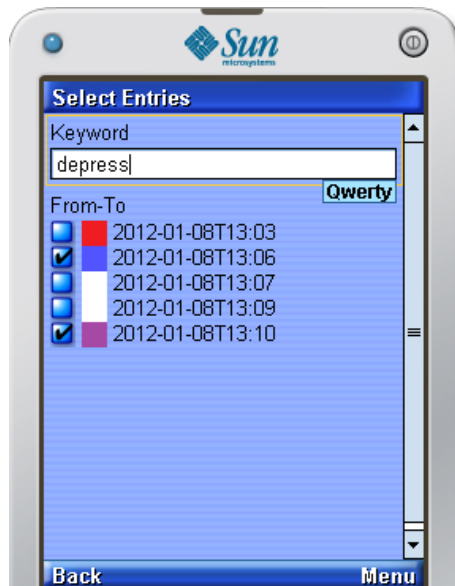
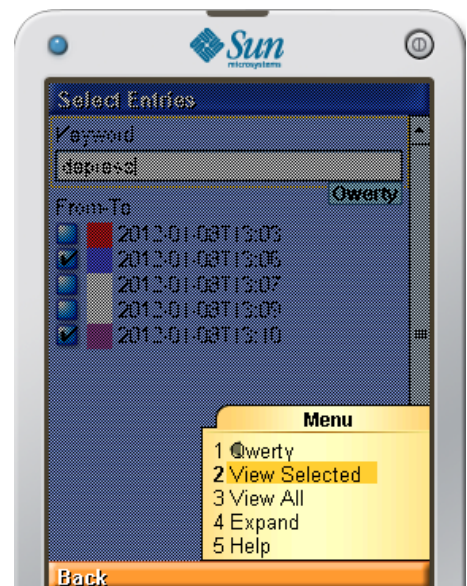


Figure 3-11J and Figure 3-11K is a case in which a user searches records by specifying a keyword depress , so wants to look for any record entry which has the word depress in a specific range of time which is from 2012-01-08T13:06 to 2012-01-08T13:10 . View Selected is selected from the Menu and the PPHR display only the entry which contains the word depress on the view screen as shown in Figure 3-11L. In Figure 3-11M, Expand is chosen from the Menu instead of View Selected , the PPHR will display another list of blocks from and to the selected blocks dates, see Figure 3-11N. The first block with turquoise colour indicates that the record entries in that block has at least one entry which contains the word depress , this way the user can easily identify when about the entry has been made. Figure 3-11O and 3-11P shows View Selected made on the block on the expanded blocks list and the record is displayed on the view screen.

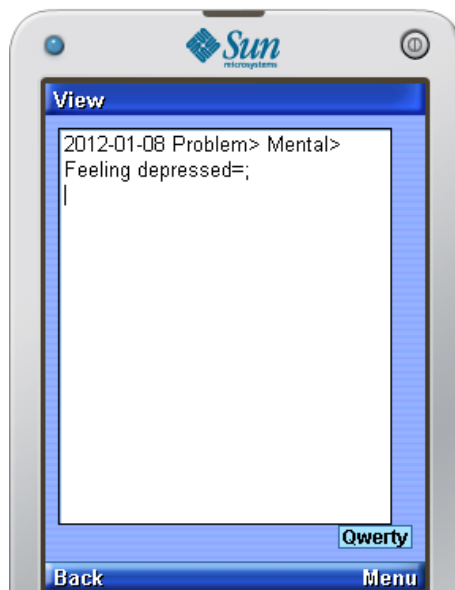
3-11J: Specify Keyword depress



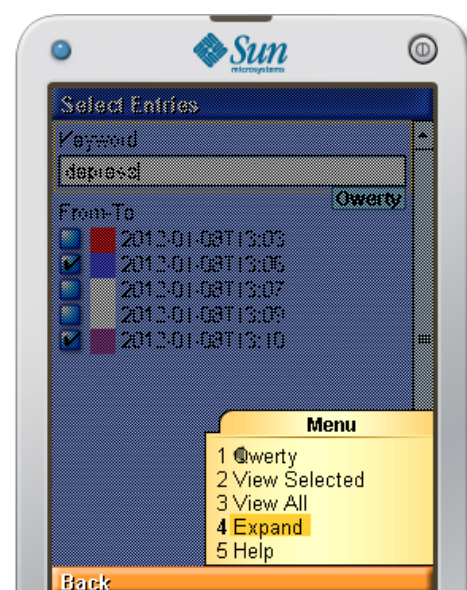
3-11K: Choose View Selected



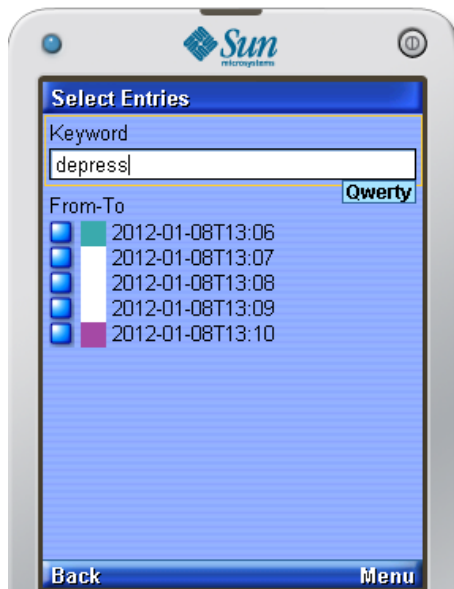
3-11L: Keyword Found in the Date Range



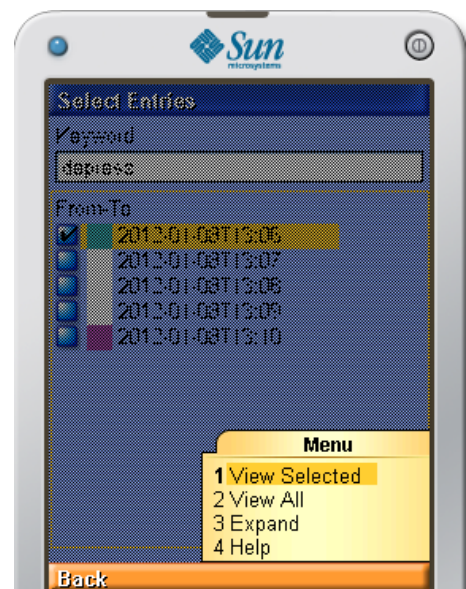
3-11M: Choose Expand



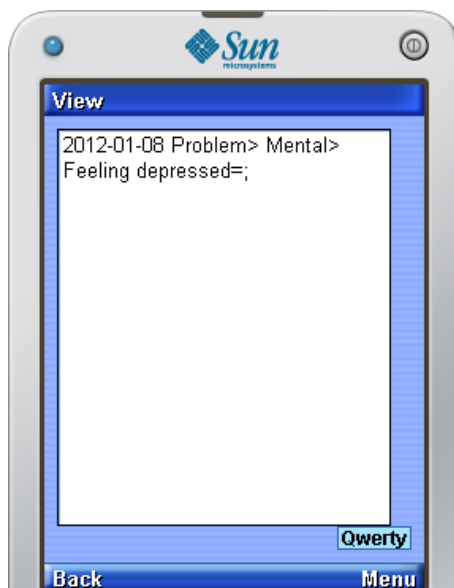
3-11N: Range Divided into New Blocks



3-11O: Choose View Selected

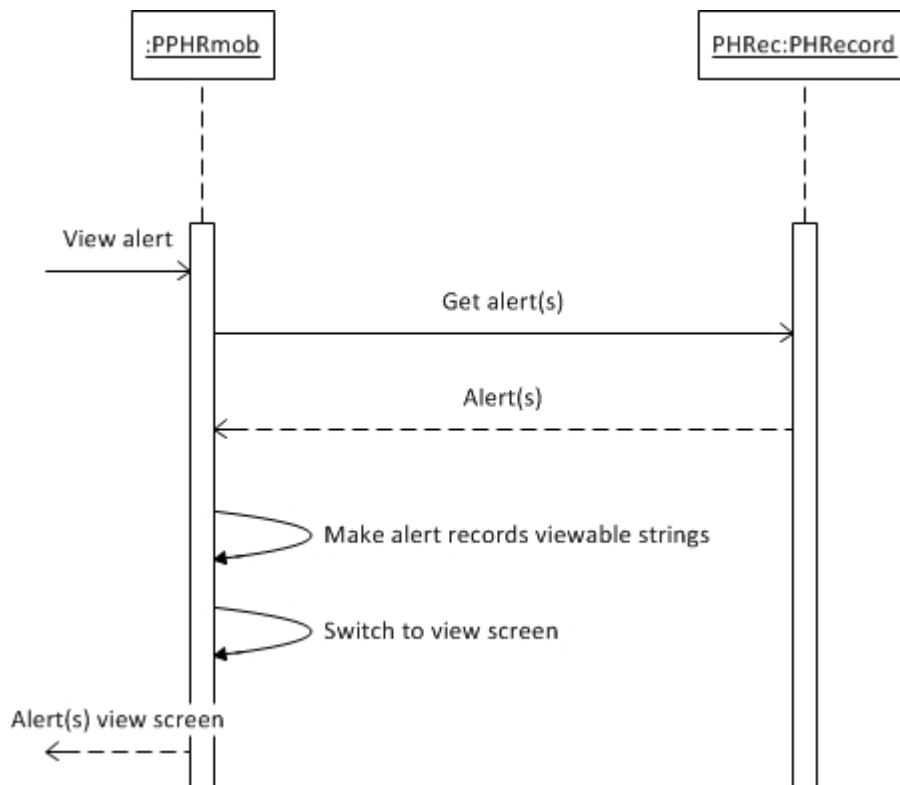


3-11P: Show Entry with Keyword depress



### 3.5.5 View Alert

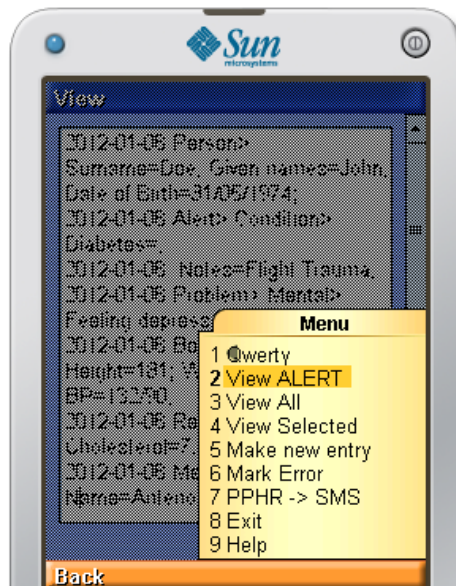
Interactions sequence between PPHRmob and PHRecord classes are as shown in Sequence Diagram- 6. When PPHRmob sends a Get alert(s) request to PHRecord, the PHRecord replies with only alert records. The PPHRmob then make the retrieved alert records into viewable strings then display it on a new screen.

**Sequence Diagram- 6: View Alert**

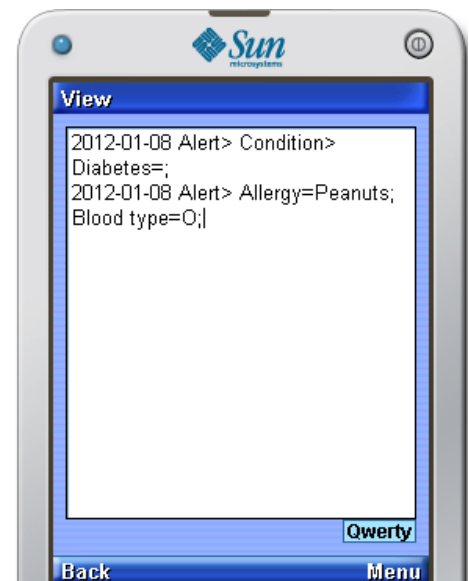
Graphic mode `View Selected` has a list of blocks with colours to indicate types of records, including alert which is represented in red colour. PPHR has also a `View Alert` which can be initiated in any view record screen to display alert entries only from the entire records on view screen, see Figure 3-12A and 3-12B. `View Alert` is available on both text and graphic mode PPHR. Figure 3-12C, 3-12D and 3-12E is another example of identifying alert type of entries in graphic mode records navigation (Sequence Diagram- 6 does not illustrate this; refer to Sequence Diagram- 5). Graphic mode navigation shows when the alert entry is made, and the user can choose to view the entry in a specific date range. The output display is different than the menu item `View Alert`; the latter contains all Alert entries, but the navigation selection only includes Alert entries in the chosen date range. Another way to view only alert type record in navigation is by using keyword; in Figure 3-12F and 3-12G, user keys in `Alert` in the key field, initiate `View Selected` command with two blocks selected, will display only alert type of records from and to the selected blocks date on the view screen as shown in Figure 3-12H.

**Figure 3-12 Find Alert**

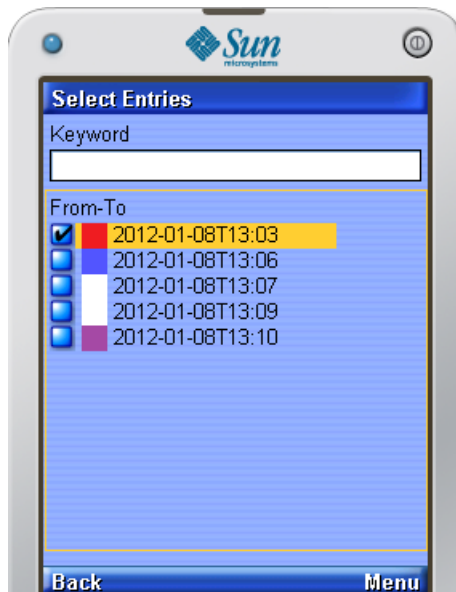
3-12A: View Alert from Record Display Screen



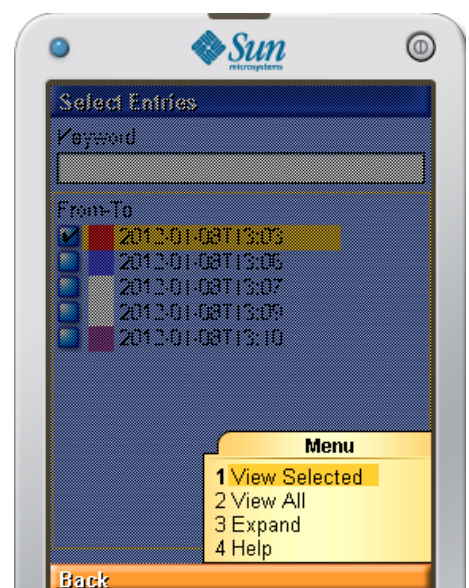
3-12B: Show All Alerts



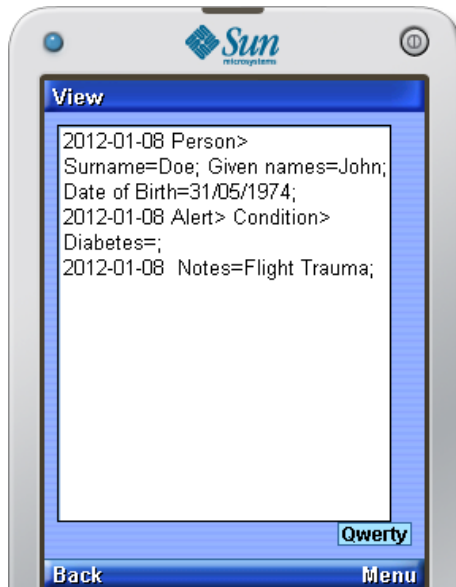
3-12C: Find Alert from GUI View Selected



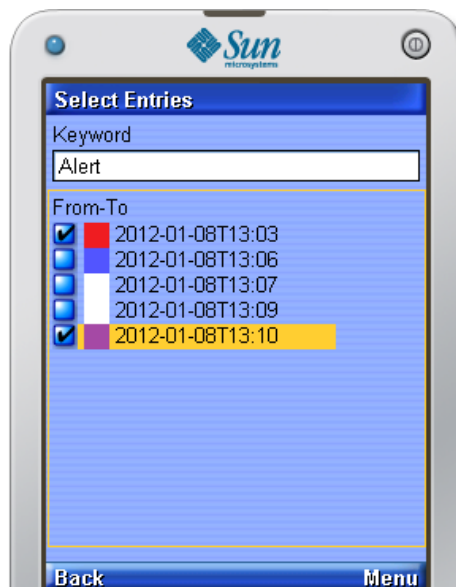
3-12D: Alert in Red Block Entry



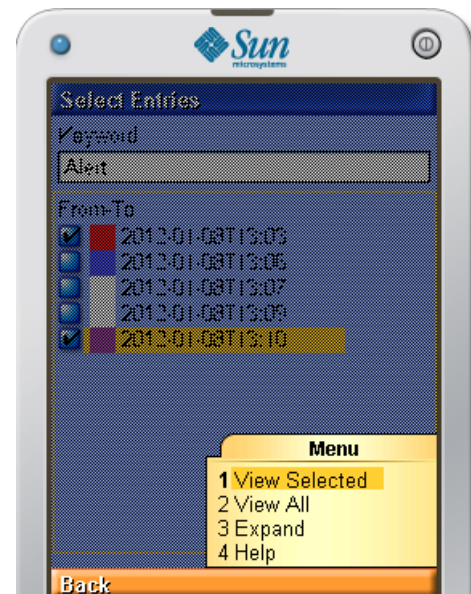
3-12E: Display Block of Entries Containing Alert



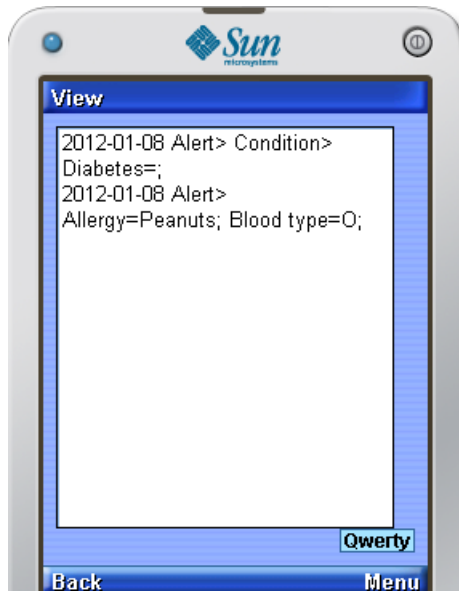
3-12F: Search for Alert from First to Last Date



3-12G: Choose View Selected



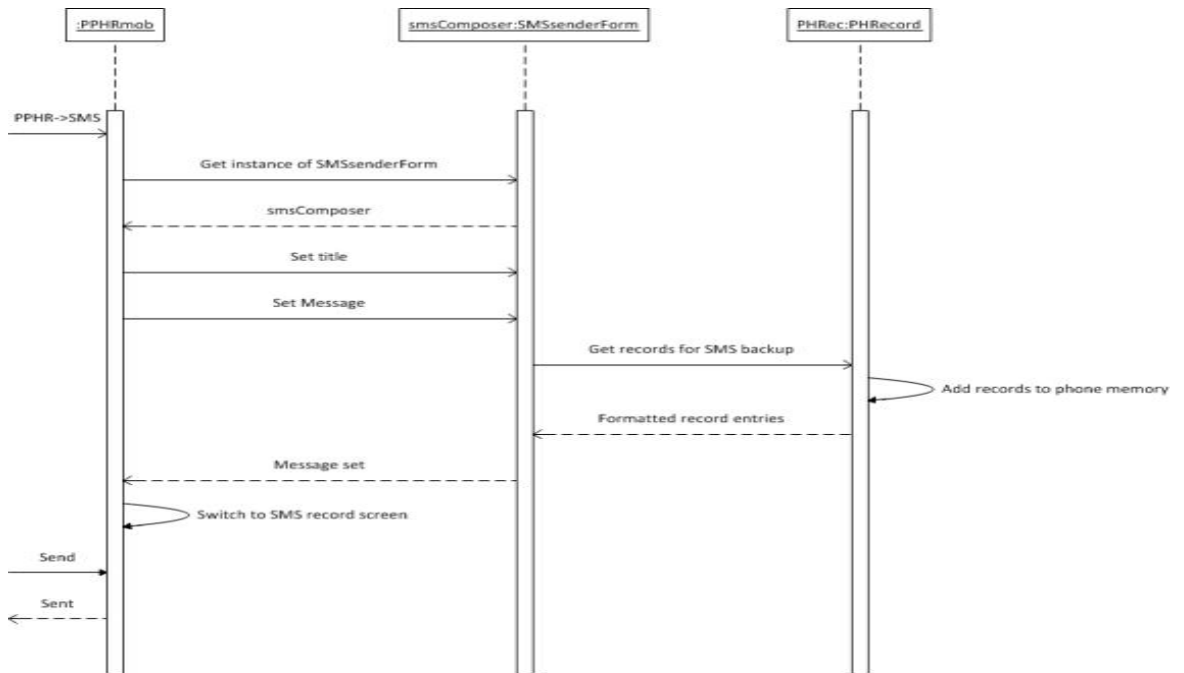
### 3-12H: Display All Entries with Word Alert



### 3.5.6 PPHR -> SMS

SMSsenderForm class is responsible to define the title, body message and gateway number for a SMS message. The PPHRmob class will send the title and the message to be set to SMSsenderForm, SMSsenderForm will then obtained formatted records for SMS backup. After message is set in SMSsenderForm and PPHRmob has been acknowledged the message and title are set, PPHRmob will display a SMS record screen and the user are able to send the message for backing up the records.

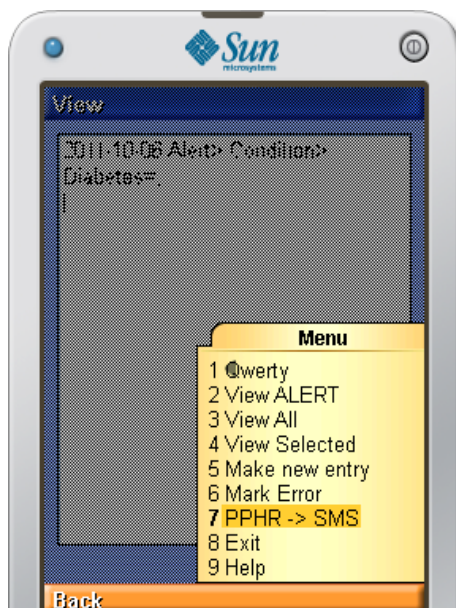
Sequence Diagram- 7: PPHR -> SMS



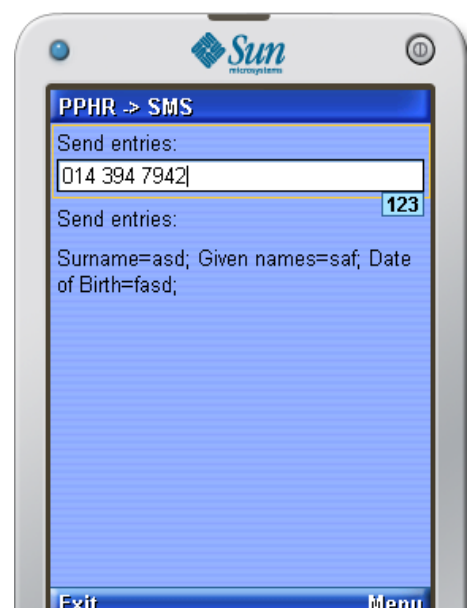
In Figure 3-13A, in View All screen, there is a PPHR -> SMS function which can be initiated to send saved data to server for backup. As mentioned the data is transferred through GSM connection, the central computer will then upload the data to the backup database using Internet. Figure 3-13B shows PPHR -> SMS screen, which includes the destination number, and content of records to be sent.

Figure 3-13 Send Data to Central Computer

3-13A: Send Data through SMS



3-13B: Send Data through SMS

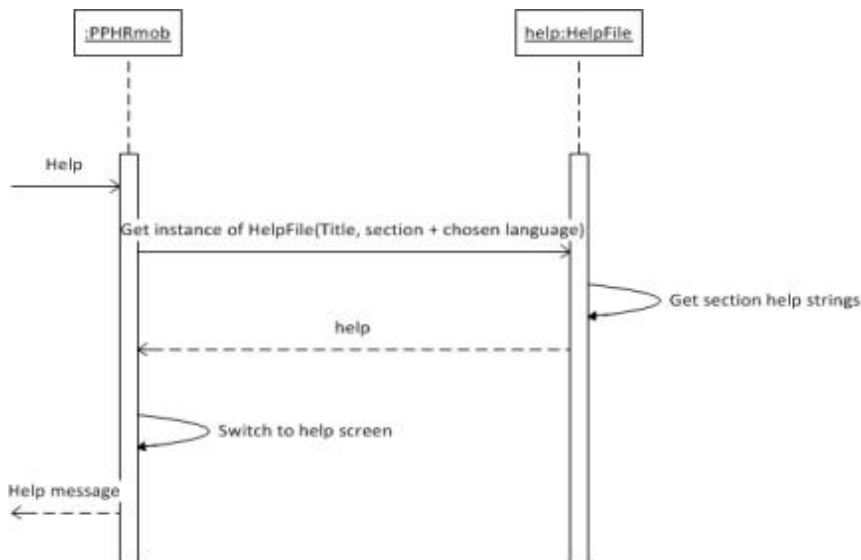




### 3.5.7 Help

When Help command is initiated, PPHRmob sends a request together with section title and chosen language for help strings from HelpFile class. HelpFile will read the help file and get the help strings according to the title then send it back to PPHRmob. PPHRmob retrieved the help strings and will display it on a new screen, see Sequence Diagram- 8 for above statements.

Sequence Diagram- 8: Help



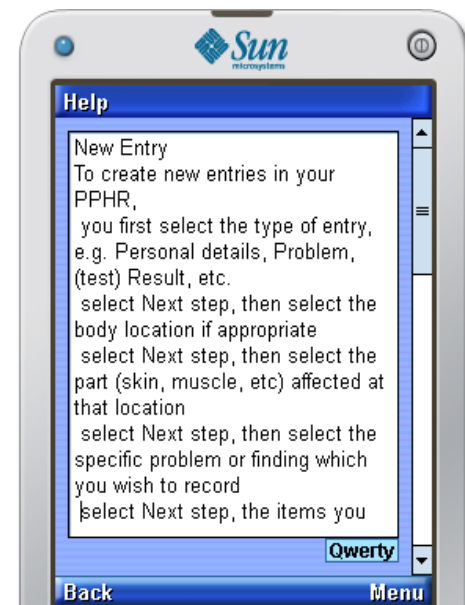
Help is available for some functions as shown in Figure 3-14, to explain the features and usages of the corresponding function. The help function is initiated by selecting Help in the Menu from the bottom right of the screen.

**Figure 3-14 Help on Various Functions**

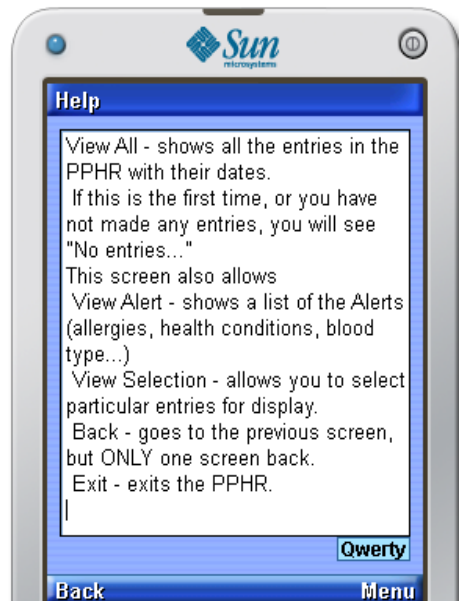
Help on Menu on Bottom Right Screen



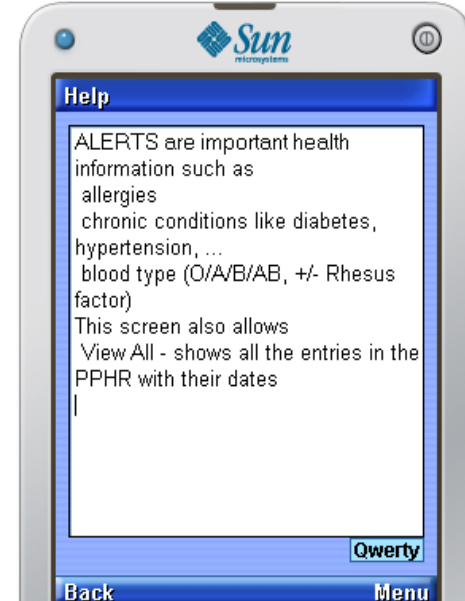
New Entry Help Screen



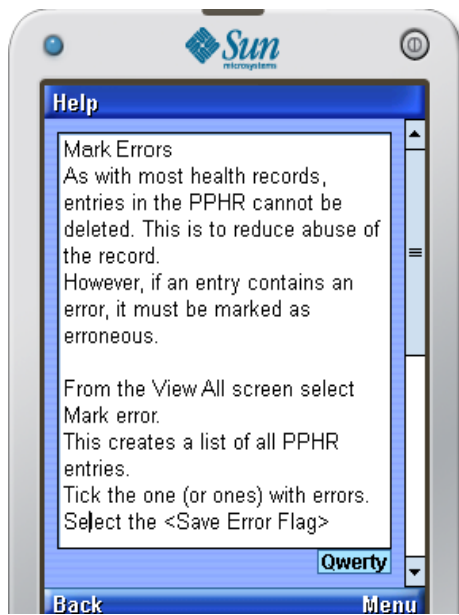
View All Help Screen



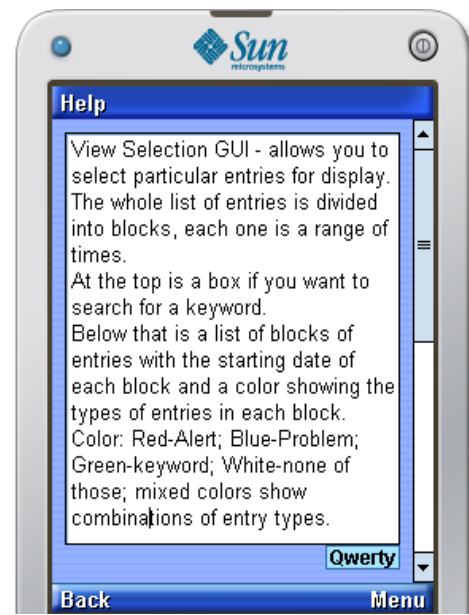
View Alert Help Screen



Mark Errors Help Screen



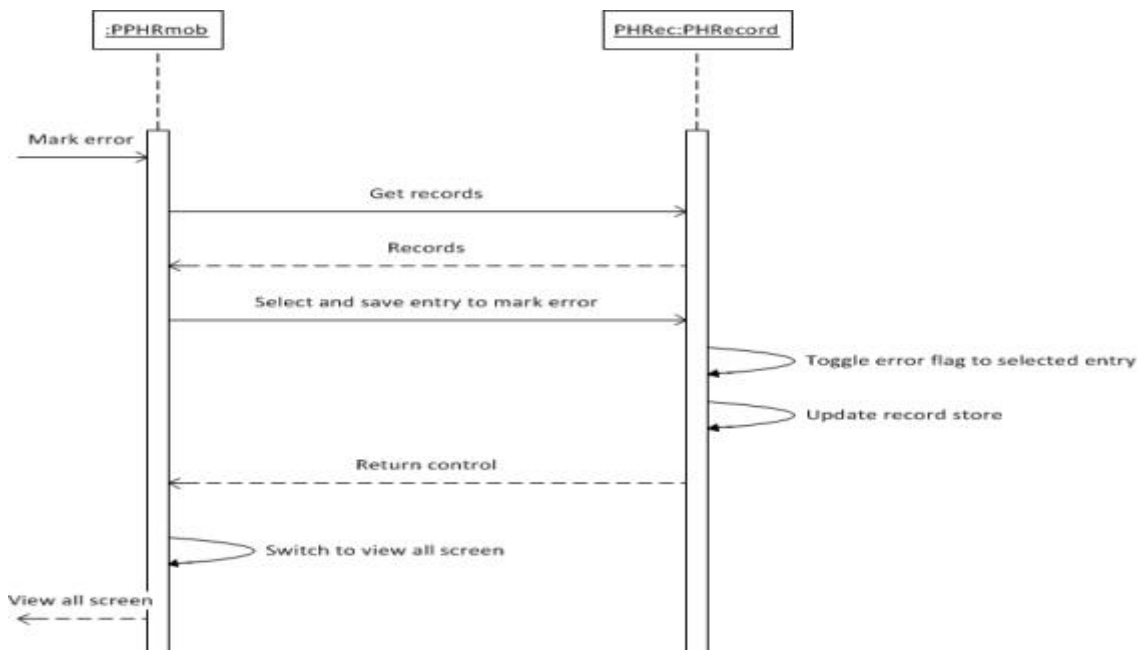
View Selected Help Screen



### 3.5.8 Mark Error Entry

To mark an entry as error, PPHRmob sends entry index to be marked error to PHRecord, PHRecord then toggles error flag to selected entry then update the record store (Refer Sequence Diagram- 9).

Sequence Diagram- 9: Mark Error



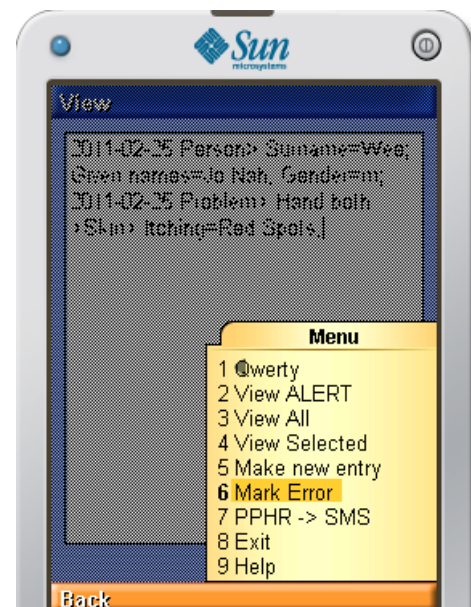
If the user enters wrong information, they are not allowed to delete it, but they are able to mark that information as erroneous data. This function can be initiated in View All or View Selected as shown in Figure 3-15A, the error marked information will be saved with an error flag to indicate that the information is incorrect. In the Menu of View All or View Selected screen, select Mark Error as shown in Figure 3-15B, a new screen will then display a list of selectable entries as in Figure 3-15C, one or more entries are allowed to be selected at once. Selected entry to be marked error can be saved by choosing Save Error Flag in the Menu as shown in Figure 3-15D.

**Figure 3-15: Mark Error on Entry with Incorrect Information**

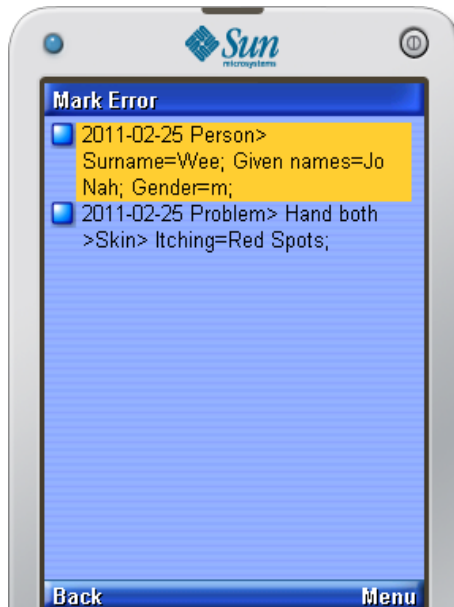
3-15A: Normal Data Entries



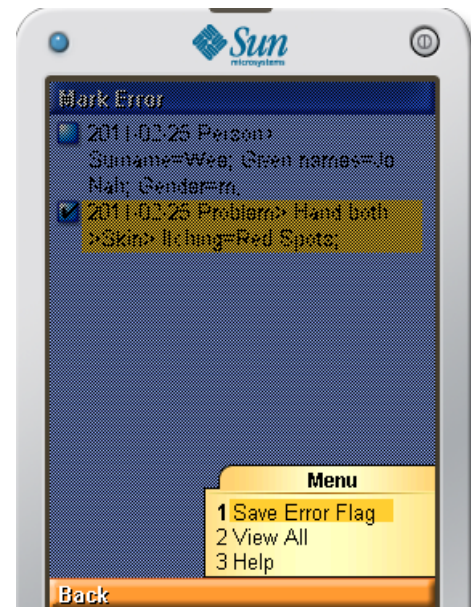
3-15B: Select to Mark Error



3-15C: Choose Entry to Mark Error



3-15D: Save Marked Error Entry



## 3.6 Evaluation

### 3.6.1 Participants

Twenty participants were chosen to evaluate the PPHR. Participants had differing ethnic backgrounds, education backgrounds, ages, genders, mother languages, familiarity with cellphones, and involvements in maintaining their own health data. A very important requirement for a user to participate in the evaluation was having a cellphone which supports J2ME platform, and has enough storage space in cellphone to store PPHR itself and the saved medical record. The other requirement of participants was that they should be Malay, English, Mandarin or Deutsch literate.

### 3.6.2 Data collection strategies

Participants who agreed to have their cellphone installed with PPHR were either given the PPHR execution file to install by themselves with complete instructions, or with the assistance of a developer. PPHR manual was given to the participants and a simple demonstration was done to ensure participants knew how to completely use the PPHR.

Evaluation form was prepared to evaluate the usability of the PPHR; it includes remarks from users for all the commands available in PPHR, such as the initiation command GO, Make new entry, View all, View alert, View selected (Text and Graphic mode), Mark error, PPHR->SMS, Help, Back, and Exit. The ratings range from 1-5 for the satisfaction of using the PPHR, where 1 means very dissatisfied,

2 means dissatisfied, 3 means neutral, 4 means satisfied and 5 means very satisfied. Participants were advised to use the PPHR for at least 4-5 days before they started to evaluate. Sample of the PPHR evaluation form is in Appendix A.

### **3.6.3 Evaluation process**

Twenty sets of data are expected to be collected in the evaluation. The data collected was used to evaluate the satisfaction of the participants and the adaptability of the PPHR. Data collected were compiled and analysed based on age group, education level and language. Satisfaction of each of the PPHR commands was compared according to different participants attributes, and each comparison will be presented in charts. Participants remarks and suggestions will be taken into discussion as a reference for future enhancements of PPHR.

### **3.6.4 Results**

Data collected was used to evaluate the performance of the participants and the adaptability of PPHR. The performance of the participants was evaluated as mentioned above. The adaptability of PPHR was evaluated based on the feedback gained from the participants, including ratings, written comments and suggestions.

**3.6.4.1 Participant Demographics****Table 3: Participants Demographic Details**

Number	Age group	Gender	Education	Native Language	Chosen Language	Race	Cellphone brand/model
1	26-55	Male	University	Mandarin	English	Chinese	Nokia 6280
2	17-25	Female	Secondary	Bahasa-Melayu	Bahasa-Melayu	Malay	Sony Ericsson K800i
3	1-16	Male	Secondary	Bahasa-Melayu	Bahasa-Melayu	Malay	Nokia 6500
4	26-55	Male	Secondary	Mandarin	Mandarin	Chinese	Nokia 6220
5	56-100	Male	Secondary	Other	Bahasa-Melayu	Indian	Samsung SCH-R640
6	26-55	Female	University	Mandarin	English	Chinese	Nokia 7230
7	26-55	Female	University	Other	Bahasa-Melayu	Iban	Sony Ericsson K810
8	17-25	Male	University	Other	English	Indian	Nokia 6300
9	26-55	Male	University	Bahasa-Melayu	English	Malay	Nokia 6680
10	26-55	Male	Secondary	Bahasa-Melayu	Bahasa-Melayu	Malay	Nokia x3-02
11	56-100	Male	Secondary	Other	Bahasa-Melayu	Iban	Sony Ericsson w200i
12	56-100	Female	University	Mandarin	English	Chinese	Nokia x3
13	56-100	Female	Secondary	Mandarin	Mandarin	Chinese	Nokia E90
14	17-25	Male	Secondary	Other	Bahasa-Melayu	Iban	Nokia 6280
15	1-16	Female	Secondary	Mandarin	Mandarin	Chinese	Nokia 3200
16	26-55	Male	University	Other	English	Iban	Sony Ericsson w950
17	56-100	Female	Secondary	Mandarin	Mandarin	Chinese	Nokia 9300
18	1-16	Female	Secondary	Bahasa-Melayu	Bahasa-Melayu	Malay	Nokia N70
19	17-25	Male	University	Other	English	Iban	Nokia 6070
20	1-16	Female	Primary	Mandarin	Mandarin	Chinese	Sony Ericsson K810

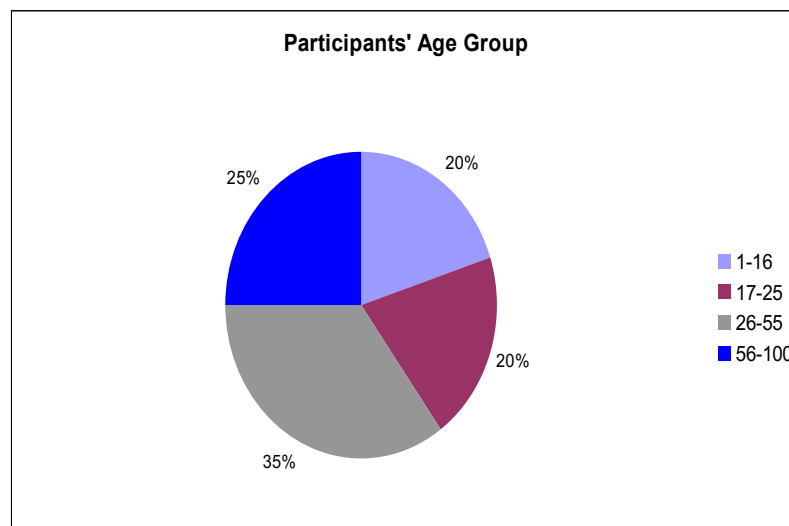
### 3.6.4.2 Participants Attributes

In order to ensure PPHR is adaptable to all kind of people, it is important to involve participants from different ages, education background and races in the evaluation. This section shows the participants age groups, genders, education backgrounds and races in charts. According to the charts, participants had a wide variety of attributes, enough to test the PPHR's general usability. The participants are rather evenly distributed across different age groups, genders, education levels, races and native languages, which are important because participants with differences between any of the attributes may influence their point of view for the PPHR usability. For example: participants of 1-16 age group might think PPHR is not completely useful to them while participants of 56-100 age group might think PPHR can be very useful for them to maintain their health data.

#### 3.6.4.2.1 Age Group

Different ages of people require different levels of medical attention and also different levels of concern on their own health status. In order to find out how well the PPHR can be adapted to people of all ages, age was divided into four age groups: 1-16, 17-25, 26-55 and 56-100. As shown in Figure 3-16, 35% of the participants were between ages 26-55, so mostly not retired, while 25% of the participants were in the retirement age group 56-100. 20% of participants were in the age group of 17-25, and 20% in the age group of 1-16 - mostly school students.

**Figure 3-16: Distribution of Participants by Age Group (20 Participants)**

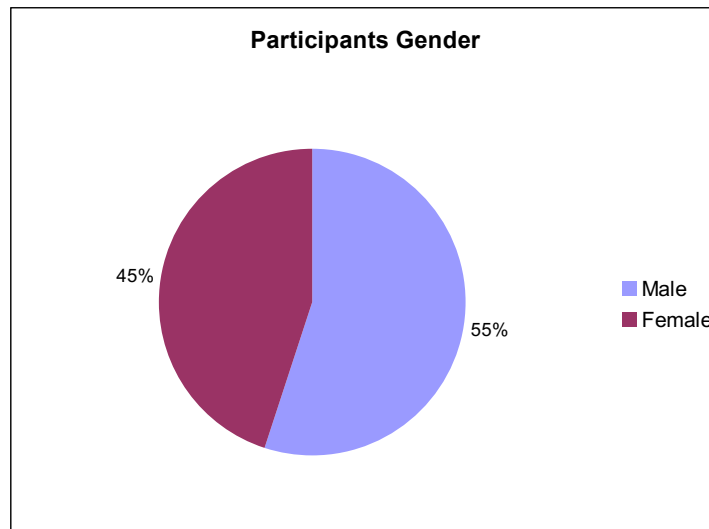




#### 3.6.4.2.2 Gender

Other than age group, gender is also one of the important attributes of participants. The PPHR includes elements which differ for males and females, such as body parts, so it is important to find out whether the PPHR data items are sufficient for both genders. Figure 3-17 shows that there were 55% male participants and 45% female participants in this evaluation, which is quite a balanced distribution.

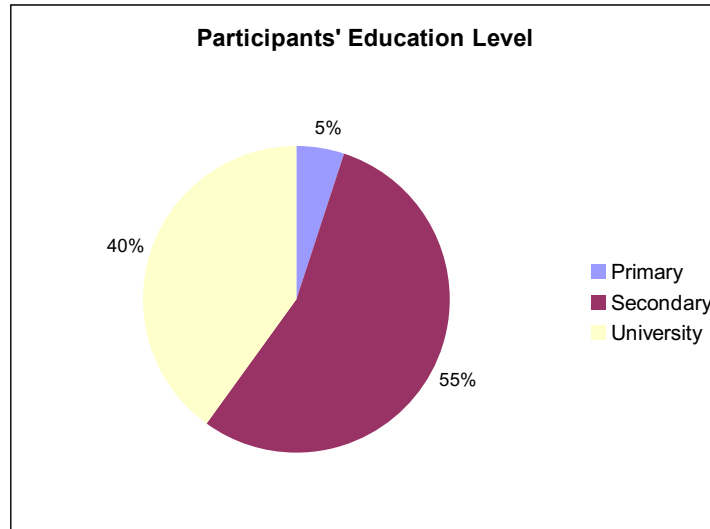
**Figure 3-17: Distribution of Participants by Gender (20 Participants)**



#### 3.6.4.2.3 Education Level

Different education levels may affect understanding of medical terms used in PPHR, and also ability to learn to use PPHR. This distribution is important to test whether the terms used in PPHR or PPHR instructions are too hard to understand, or are suitable for people of all education levels. On the other hand, involvement of this participant distribution can also test whether education level affects people's concerns in maintaining their own health status. Figure 3-18 shows the percentages of participants with either primary, secondary or university education level.

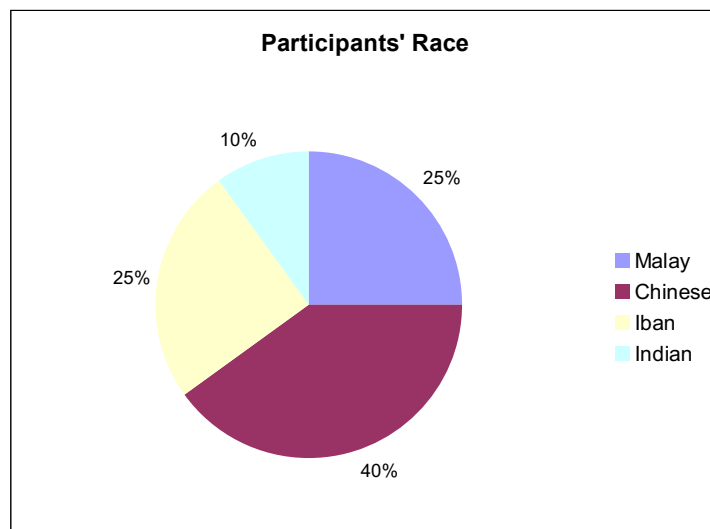
**Figure 3-18: Distribution of Participants by Education Level (20 Participants)**



3.6.4.2.4 Race

Malaysia is a multiracial country; since the PPHR are mainly designed for people in Malaysia, it is crucial to include all races in the evaluation. Figure 3-19 shows that most participants were Chinese, followed by Malay and Iban, then Indian. PPHR-provided languages do not include native languages of Iban and Indian, so the Iban and Indian participants had to choose a language which suited them.

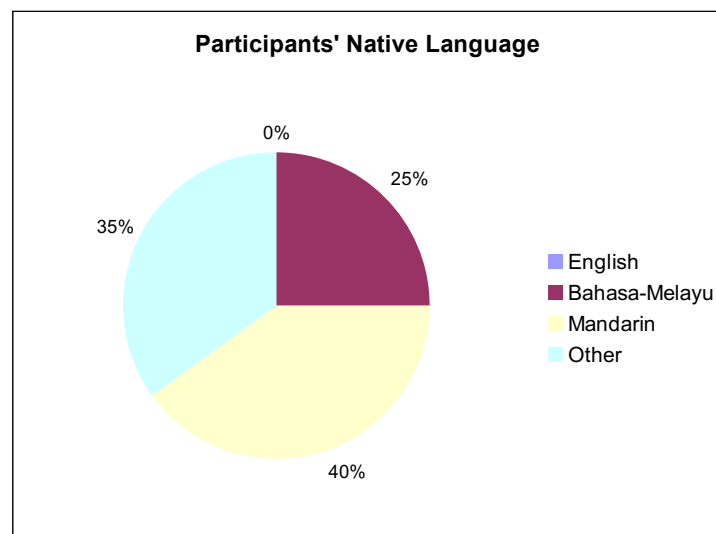
**Figure 3-19: Distribution of Participants by Race (20 Participants)**



#### 3.6.4.2.5 Native Language

PPHR has been implemented to be able to work in four different languages: English, Mandarin, Bahasa Melayu and Deutsch. As shown in Figure 3-20, none of the participants had English as their native language, but Malaysia has a lot of people who are English educated or can understand English well. This distribution is important to test whether medical terms and instructions in PPHR of different languages are suitable for understanding by all people with different native languages.

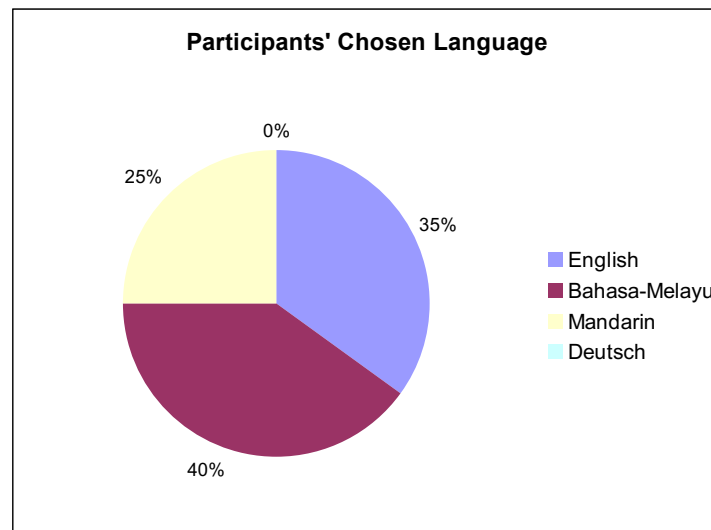
**Figure 3-20: Distribution of Participants by Native Language (20 Participants)**



#### 3.6.4.2.6 Chosen PPHR Language

This distribution can be used to test which languages are used more for PPHR including the races that do not have their native language listed in PPHR. This also can test the participants who could not or did not choose their native language - are they able to fully use PPHR in their chosen language? According to Figure 3-21, Bahasa-Melayu is the most chosen language, followed by English then Chinese. There are 0% of participants who chose Deutsch as none of the participants were literate in Deutsch at all.

**Figure 3-21: Distribution of Participants by Chosen Language (20 Participants)**



#### ***3.6.4.3 Overall Commands Rating Results***

Commands rating are for the purpose of checking whether all the commands provided in PPHR are suitable to the users. All the commands names are designed to be meaningful and in simple terms, the arrangements of the commands locations on the cellphone's screen and their usages are all taken into design considerations to maximize the usability of PPHR. In order to make sure provided commands of PPHR are suitable for all the users, especially users in Malaysia, which is multiracial and multicultural with different native languages and education levels, tests on each command are made. Participants were asked to rate the commands with the scaling of 1 as terrible, 3 as OK and 5 as great, the commands rating are mostly based on usability. Participants were also allowed to make any remarks or suggestions on each command for improvements purpose, although not all participants gave comments to every command and entry type. Some of the comments are non-English, so translations had been made.

This section divides commands into 4 categories: commands for Make New Entry , View Selected (Text Mode) , View Selected (Graphic Mode) and others. Make New Entry is an important section of PPHR for users to enter new data. It consists of a big list of element items, which includes most of the elements in ICPC2e. Visualization of body parts and sizes in anatomy image is also initiated from one of the sub-commands in Make New Entry .

Another important section of the PPHR is View Selected , this command allows users to navigate a range of record entries by keywords, alert or problem type. Evaluation of View Selected has been done on both text and graphic mode; text mode requires more steps to complete the navigation while graphic mode is designed to save time and be more intuitive. Since the graphic mode has a totally different way of presenting record navigation, the test is able to show how effective the improvements had been done on View Selected (Text Mode) in participants perspective.

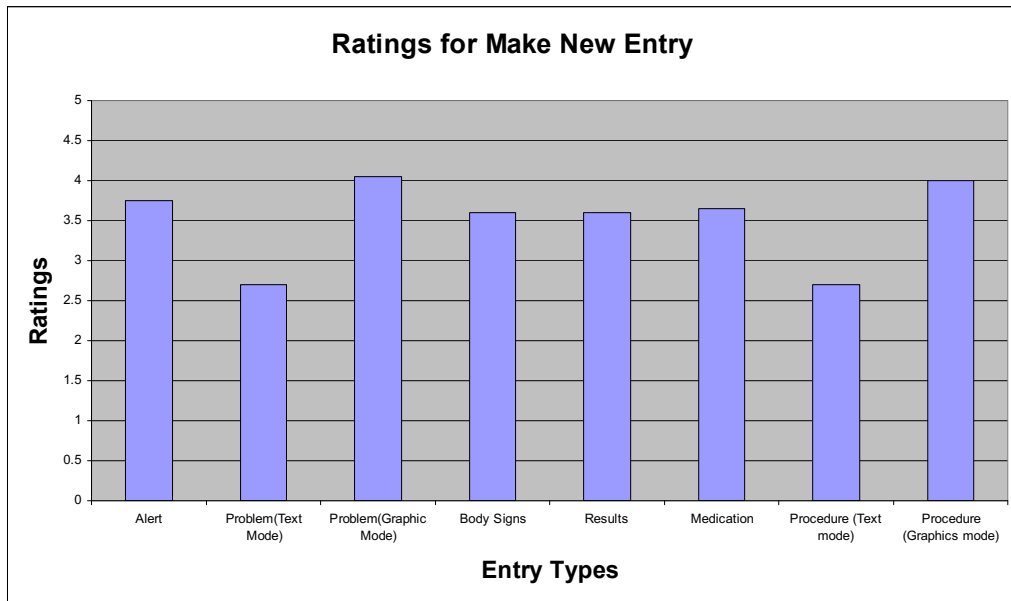
Other tested commands include commands to go back to previous screen, display help instructions, send saved records through SMS, view alert entries or all entries, mark entries as error, and exit the PPHR.

#### 3.6.4.3.1 Make New Entry

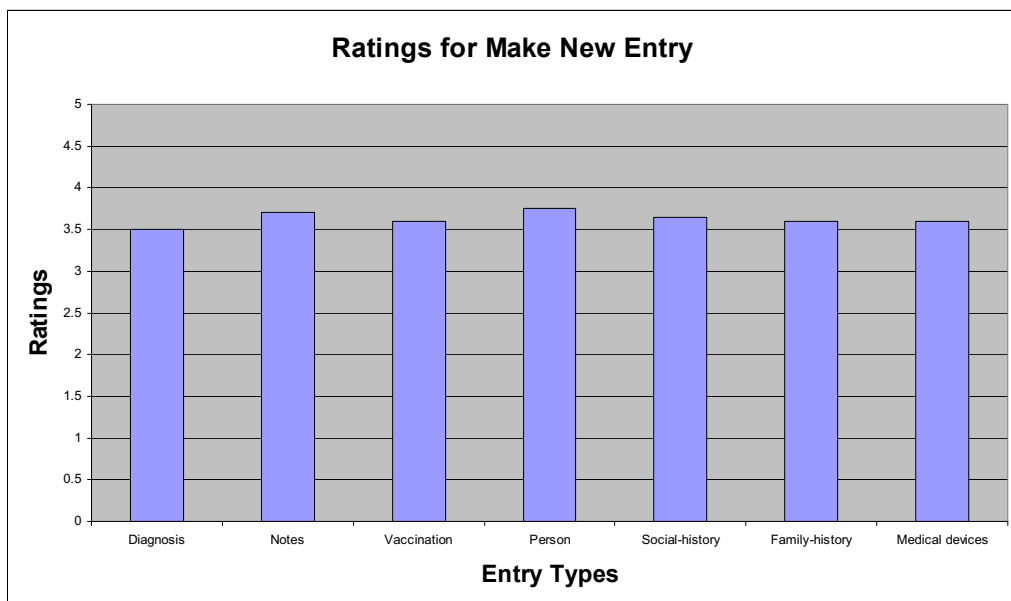
Make New Entry presents a big list of entry types; types include alert, problem, body signs, results, medication, procedure, diagnosis, notes, vaccination, person, social history, family history and medical device. With the entries divided into types, users can easily get the related entry list of the information they want to save without consuming too much time. Figure 3-22 and Figure 3-23 show the ratings result of making a new entry according to types of data. The ratings are based on the interface, usability, and also sufficient entries of each type so that the users can get related entries which they want to save.

According to the ratings result of Make New Entries , most of the ratings for making each entry type are above average 3 which is OK, as mentioned 1 Terrible, 3 OK, 5 Great. It seems that problem and procedure type of entries which are presented in text do not get ratings higher than 3, while graphic version of presenting problem and procedure entries have better ratings.

**Figure 3-22: New Entries Ratings (First Part) (20 Participants)**



**Figure 3-23: New Entries Ratings (Second Part) (20 Participants)**



Refer to Table 4 for the comments of the users. Although problem and procedure in graphic mode have higher ratings, there are still things to be improved, and so do the others. For text mode problem and procedure entry types, according to the remarks the wordings are not as clear compared to presenting it with an image. List of items presented in problem and procedure text mode are known to be too long, and is hard to find as it is also not in alphabetical order. For other entry types to be selected in Make

New Entry , most of the suggestions are about ease of making selections or more selections to be included instead of typing them in manually.

**Table 4: Remarks/Suggestions for “Make New Entry”**

Commands	Comments
Alert	<ul style="list-style-type: none"> <li>• I can t find some of the alert I want to enter.</li> <li>• Can make a list of blood types to be selected instead of typing it myself.</li> </ul>
Problem (Text mode)	<ul style="list-style-type: none"> <li>• The list is too long.</li> <li>• My phone hanged when loading the list.</li> <li>• It is hard to spot the body part I want to find.</li> <li>• The list should be in alphabetical order.</li> <li>• Where exactly is Food-Digestion?</li> <li>• If I have a heart pain, should I choose Chest or Heart-Circulation? Should specify internal or external.</li> <li>• I can t find my problem listed after selecting sides, I shall be able to enter it manually.</li> </ul>
Problem (Graphics mode)	<ul style="list-style-type: none"> <li>• I can t find my problem listed after selecting sides, I shall be able to enter it manually.</li> <li>• I am more got used to crosshair on screen.</li> <li>• It could be better if touch screen is allowed.</li> <li>• I would rather use text selection mode in an old phone.</li> </ul>

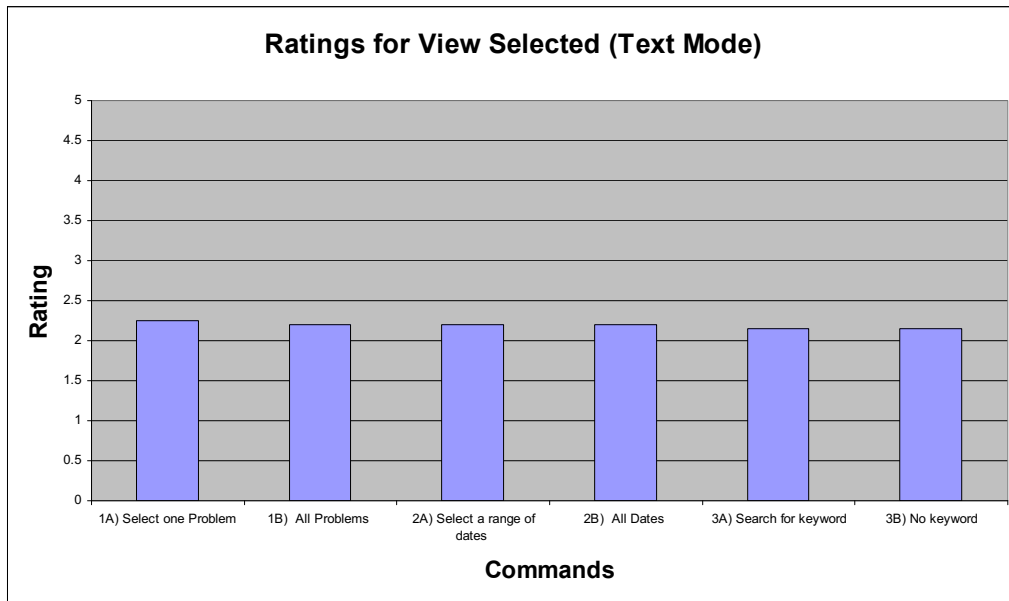
Body signs	<ul style="list-style-type: none"> <li>• The software shall let users to be able to enter all body sign information at once instead of keep on selecting and entering the information one by one. Can leave the others blank if not used.</li> </ul>
Results	<ul style="list-style-type: none"> <li>• It will be even better if I can save a photo of my x-ray result together with the information.</li> <li>• The blood result list should have more selection items.</li> </ul>
Medication	<ul style="list-style-type: none"> <li>• I can't find a place to include the side effect of medication that I felt after taking it.</li> </ul>
Procedure (Text mode)	<ul style="list-style-type: none"> <li>• List is too long to be selected.</li> <li>• Left, Right, Both can combined with the body part list.</li> <li>• The list should be in alphabetical order.</li> </ul>
Procedure (Graphics mode)	Similar to Problem (Graphic Mode)
Diagnosis	<ul style="list-style-type: none"> <li>• Should do the same like graphic mode Procedure and Problem.</li> <li>• The list is way too long</li> </ul>
Notes	Does not seem to be much useful since there are Others .
Vaccination	It could be easier to find if the list is in alphabetical order, so do the others.



Person	<ul style="list-style-type: none"> <li>• Provide more text field to enter alternate information such as alternate email or phone numbers.</li> <li>• Since these details are fixed, why need selections? Should just get to the text field form instead of selection list.</li> </ul>
Social-history	<ul style="list-style-type: none"> <li>• No Others in this section, I can't enter my diet status.</li> <li>• The terms in Social-history are very unclear, not too sure what they mean.</li> </ul>
Family-history	<ul style="list-style-type: none"> <li>• Since there is only one option to choose from, why don't just go to the form directly to insert text?</li> <li>• Should make a list of common family-history to be select from.</li> <li>• Too few choices to be selected.</li> </ul>
Medical devices	(No Comments)

#### 3.6.4.3.2 View Selected (Text Mode)

The View Selected (Text Mode) is initiated to navigate the records saved previously by PPHR. The process flow of navigating records goes step-by-step from selecting range of problems, and then dates, and finally keyword(s) (refer Section 3.5.4.1). Based on the participants' ratings, the result is not too good as the ratings are evenly below average. Although the ratings are not as bad as terrible but according to the comments given as shown in Table 5, most participants think that navigating entries by View Select (Text Mode) consumes too many steps and some of the steps might not be needed.

**Figure 3-24: View Selected (Text Mode) Ratings (20 Participants)****Table 5: Participants' Comments on "View Selected (Text Mode)"**

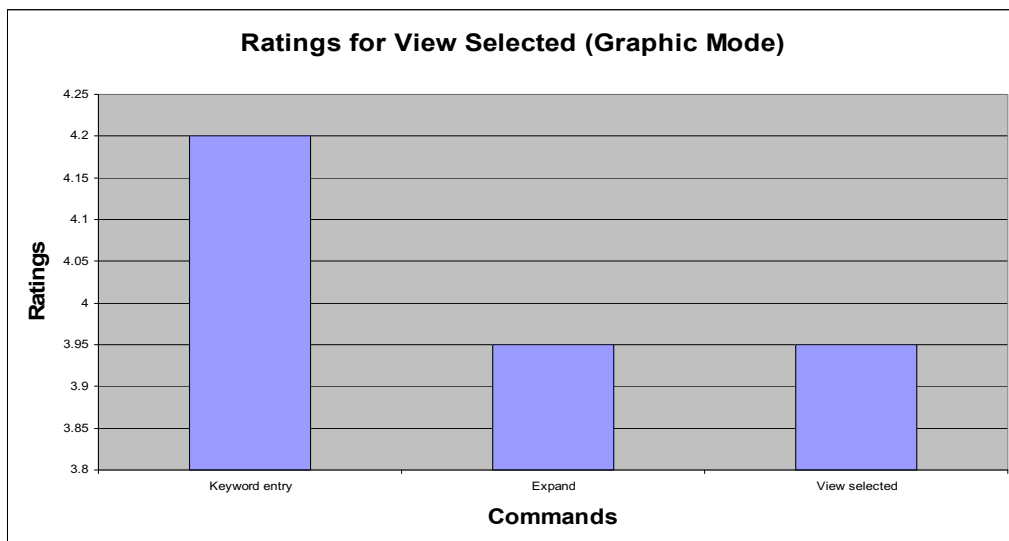
Command	Comments
1A) select one Problem	<ul style="list-style-type: none"> <li>I was not looking for problem and I have to go through this step every time.</li> <li>Problems can be categorized and squeeze all of the problems, dates and keyword field in one screen.</li> <li>Confusing</li> </ul>
1B) do not select a specific Problem - All Problems	Confusing
2A) select a range of dates to view	(No Comments)
2B) do not select any particular date range All Dates	(No Comments)
3A) search for a keyword in the record	<ul style="list-style-type: none"> <li>The keyword field can be smaller, and the date selections can be under or above the search keyword field.</li> </ul>
3B) do not search for any specific keyword (leave that field blank)	<ul style="list-style-type: none"> <li>This whole process takes too many steps to be done.</li> </ul>

	<ul style="list-style-type: none"> <li>• I don't need some of the steps such as looking for problems but I must go through it. If I was not sure what I was looking for, I have to keep repeating these steps to repeat the search.</li> </ul>
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### 3.6.4.3.3 View Selected (Graphic Mode)

View Selected (Graphic Mode) as discussed in Section 3.5.4.2, fit almost everything in one screen, and allows the users to have a clear view on where about specific record entries were. This command can produce exactly the same output as text version of View Selected. The graphic version of View Selected command reduces many steps compared to the text version, and also allows the user to navigate data in more detail. View Selected (Graphic Mode) has three sub-commands, Keyword entry, Expand and View selected. Keyword entry is basically a text field to input keyword, Expand is to expand a date block which holds a range of dates until the next block, and View Selected is to display the filtered and selected entries. The participants ratings for View Selected (Graphic Mode) are all above average, according to Figure 3-25, Keyword Entry has the best ratings, while ratings for Expand and View Selected are the same.

**Figure 3-25: View Selected (Graphic Mode) Ratings (20 Participants)**



According to participants' comments in Table 6, more suggestions are made on the Expand, it seems that there are participants who think that expanding blocks can be

improved by improving the ease of reading the date of blocks. There are also ideas about changing the date format and a preview of expanding blocks. As for the

Keyword entry , there is a user requested to be able to search for multiple keywords from the entire records. There is no comment given on View Selected by any of the 20 participants.

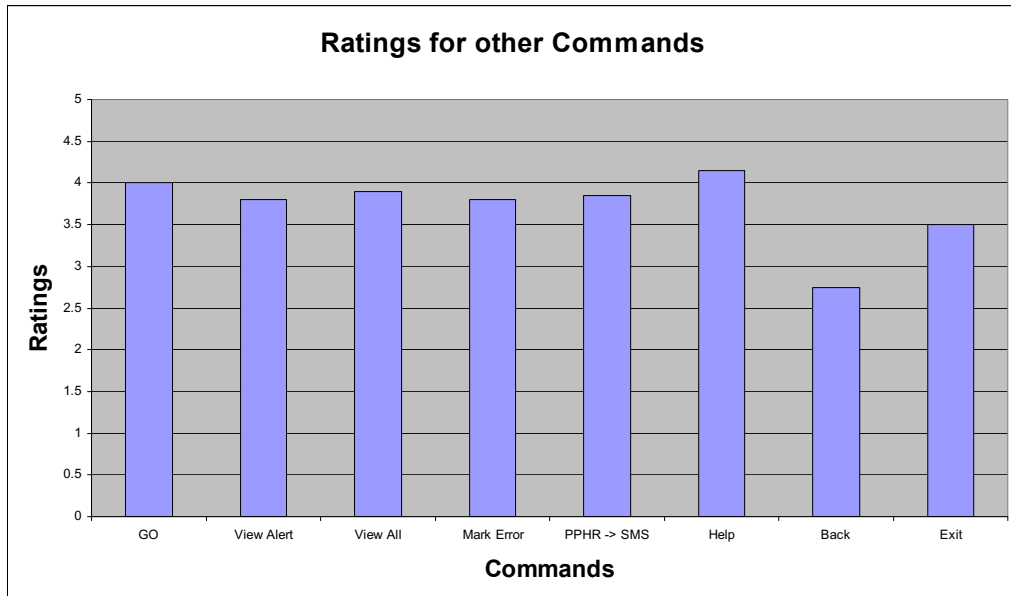
**Table 6: Participants' Comments on "View Selected (Graphic Mode)**

Command	Comments
Keyword entry	Can search for multiple keywords at once
Expand	<ul style="list-style-type: none"> <li>• Will be good if can see a preview of next expanded list before expand.</li> <li>• The dates are confusing to read, don't know which expand level I am currently in.</li> <li>• If possible, presents the expanding in different ways, like a file listing hierarchy way in Windows OS, it is easier to read.</li> <li>• The date format is a bit hard to read, can change it to a simpler one.</li> </ul>
View selected	(No Comment)

The comment about multiple keywords shows a defect in the instructions, as this is actually possible up to 5 keywords may be entered at once.

#### 3.6.4.3.4 Other Commands

Other command like GO only appears once in PPHR that is on the first screen to select language and mode. View Alert and Mark Error only available in the Menu of record viewing screen and View All is initiated to view all saved records, excluding the ones with error flag. Help, Back and Exit are available in almost every screen. According to Figure 3-26, every commands ratings are above average except Back.

**Figure 3-26: Other Commands Ratings (20 Participants)**

According to Table 7, the Back command was reported to not work on some phones, which might be the reason why the participants ratings for Back is lower than average. As for Help, View All and View Alert, there are some suggestions on making the records so that it is easier to read on cellphone screen, approaches include using a separator or by using colours. For the GO command, there is a suggestion that user shall be able to switch between text and graphic mode anytime they want in PPHR. The wording for Malay language should be changed from Bahasa\_MY to Bahasa Melayu or Melayu as a more formal term. There are no comments for PPHR->SMS and Exit commands.

**Table 7: Participants' comments on other general commands**

Command	Comments
GO	The mode should be able to switch anytime when using PPHR. The wording Bahasa_MY should be changed for better understand such has Melayu
View Alert	If there are many alerts, it will be hard to read, use a separator between each records or different colours.
View All	Records between each other should have different colours so that it will be easier to read.
Mark Error	There should be a way to unmark the error.
PPHR->SMS	(No Comment)
Help	Each block of text can use different colour to make it easier to read.
Back	Sometimes it doesn t work It doesn t go back to previous screen
Exit	(No Comment)

The comment about unmarking the error shows a defect in the instructions, as this is actually possible.

#### ***3.6.4.4 Overall Usability Evaluation Result***

This section shows the evaluation result for PPHR instructions, element items sufficiency, speed of making new entry, and navigate entries, ability of getting wanted information, and overall satisfaction ratings for PPHR. The results are based on overall participants regardless of age groups, education levels, races or languages.

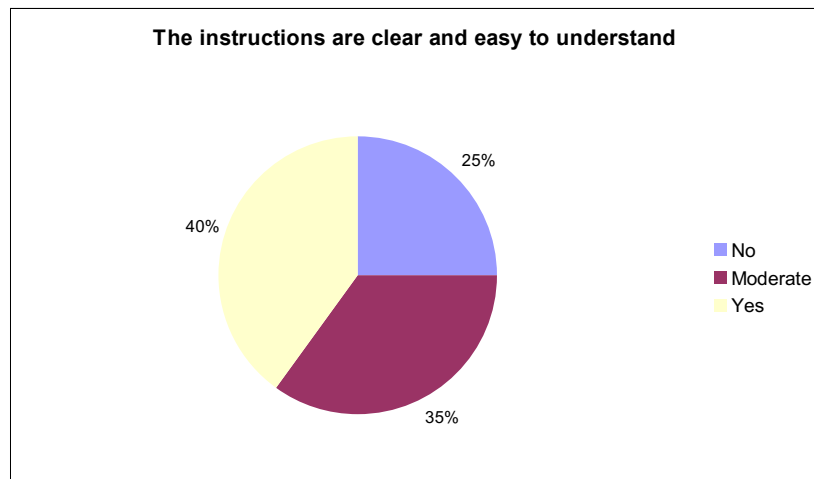
##### **3.6.4.4.1 PPHR Instructions**

This test reflects the usefulness and readability of instructions prepared for PPHR. The instructions include PPHR manual given to the participants and the help provided for each PPHR commands. Instructions help PPHR users to understand the usages of each commands or screen of PPHR. With proper instructions, users are able to learn

how to use PPHR in a short time, find out what PPHR can do for them and operate PPHR effectively such as entering or navigate records in short time.

As shown in Figure 3-27, there are 75 % of participants who gave the usefulness of the instructions above-average ratings. 40 % rated that the instructions given are clear and easy to understand, while 35 % of them thought the instructions are moderately clear and easy to understand. On the other hand, 25 % of the participants thought that the instructions are not as helpful, as they do not find the instructions to be clear enough. The overall rating result is that the prepared instructions are suitable to more than half of the people of all of ages, races and education levels.

**Figure 3-27: Overall Ratings on PPHR Instructions (Manual and Help) (20 Participants)**

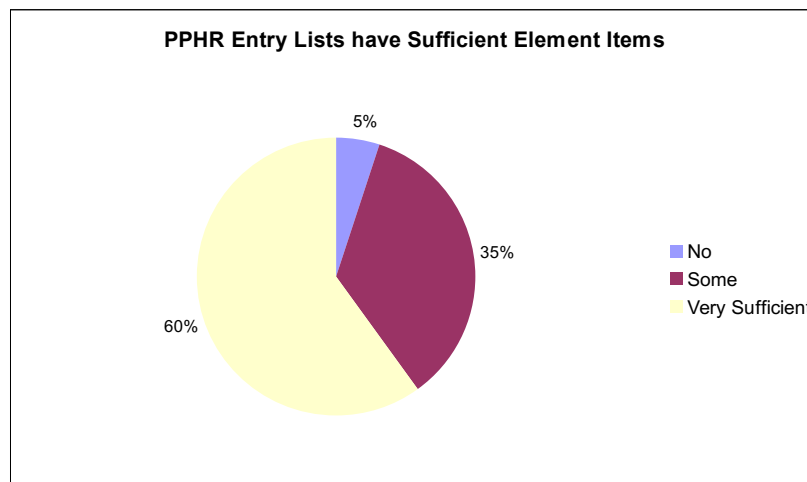


#### 3.6.4.4.2 PPHR Element Items Sufficiency

This is a question to test whether ICPC2e elements in PPHR, and others which are custom created, are sufficient for the participants to describe their health data. This is an important test as the PPHR is running on a cellphone and most of the operations are by choose and select from list. If the elements are not sufficient to satisfy users need, users would have to type in the whole record entry by themselves which is slow especially with cellphone keypad and small display screen. Other than that, the entered record entry must be in certain format, so PPHR shall have sufficient elements for the users to avoid this kind of inconvenience.

The chart in Figure 3-28 shows that 60 % of the participants think that PPHR has very sufficient element items while 30 % think that some element items they need are missing from the list. Only 5 % (one participant) think that the PPHR has insufficient element items.

**Figure 3-28: Overall Ratings on PPHR Element Items Sufficiency (20 Participants)**



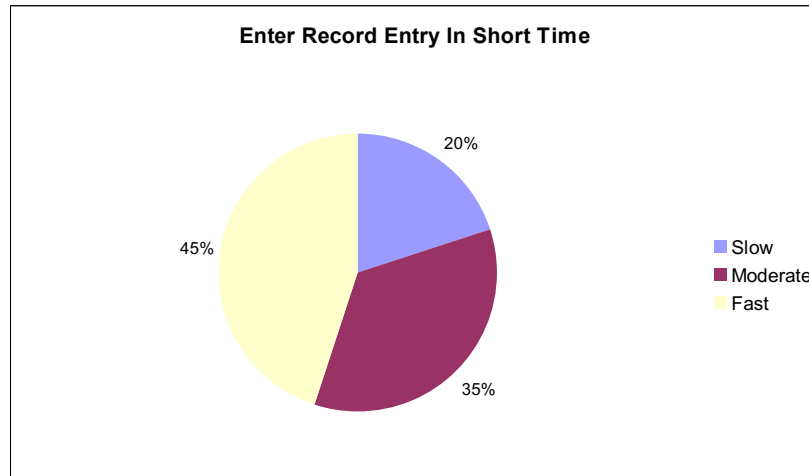
#### 3.6.4.4.3 Speed of Making New Entry

Speed of making new entry with PPHR is very important as it directly influences the effectiveness of the PPHR to manage health records. Of course, speed for making a new entry might depend on the familiarity of the users to PPHR but usability also takes an important role of speeding up the process. All the participants were requested to fill up the evaluation form only after using the PPHR for at least four days, so the participants were assumed to be familiar with the PPHR already.

Figure 3-29 shows that 45 % of the participants can make a new entry very fast, and 35 % of them make new entry in moderate speed. Moderate speed is not counted as a bad feedback because moderate speed of entering entry does not count as ineffective. 20 % of the participants found it slow for them to enter record entry.



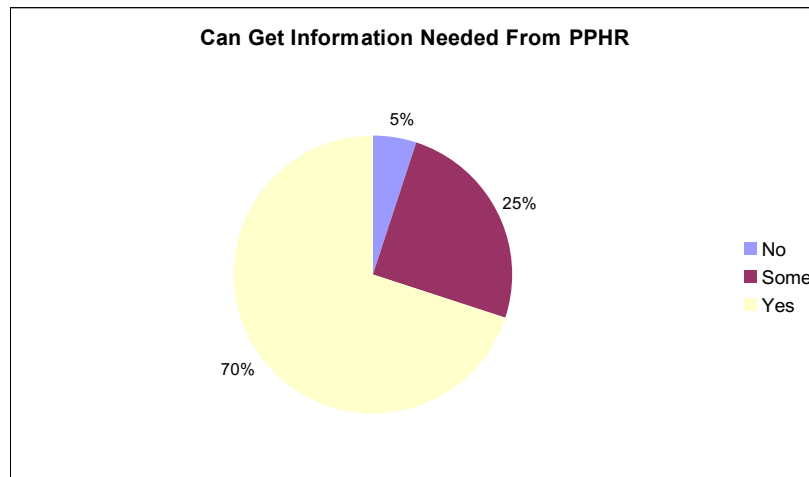
**Figure 3-29: Overall Ratings on Speed of Making New Entry (20 Participants)**



**3.6.4.4.4 Ability to Retrieve Wanted Information**

After users enter loads of medical data, it is important for them to be able to access the data. Large chunks of data are stored in cellphone in order to retrieve them users need to know where in PPHR to initiate a command to retrieve wanted information. This question tests the usability of PPHR where the users can retrieve information with ease. As seen from the chart in Figure 3-30, 70 % of participants can get information needed from PPHR, 25 % can get some of the information while 5 % of the participants cannot.

**Figure 3-30: Overall Ratings on Ability to Retrieve Wanted Information (20 Participants)**



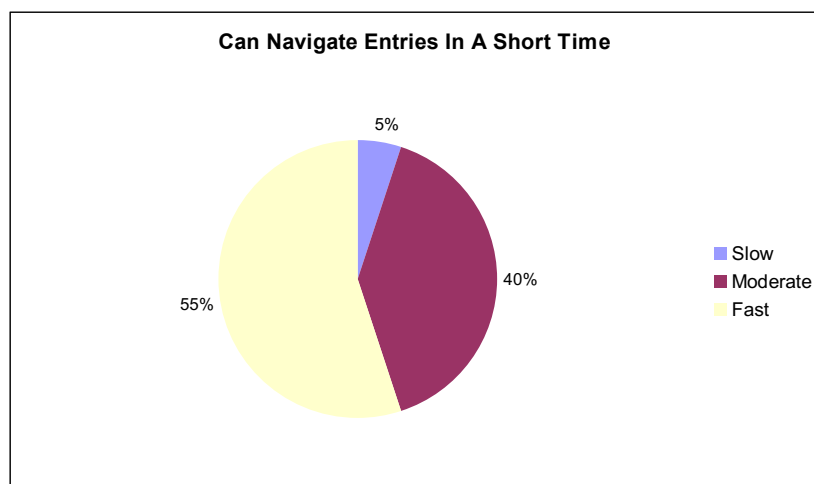
**3.6.4.4.5 Speed of Navigating Records**

Retrieving information needed is important but if the process of retrieving records consumes too much time, it would be too ineffective. As similar to speed of making new entry, speed can be decided by familiarity, but as mentioned participants are assumed

to be familiar with the PPHR already. So this test is mainly testing the time taken to navigate records based on PPHR usability.

Figure 3-31 shows that 55 % of the participants can navigate records fast, 40 % of participants can navigate records in moderate speed, and 5 % took a long time to do that. According to the result, PPHR records navigation can be counted as effective due to the reasons of various limitations such as cellphone screen size, memory, storage space, and control keys.

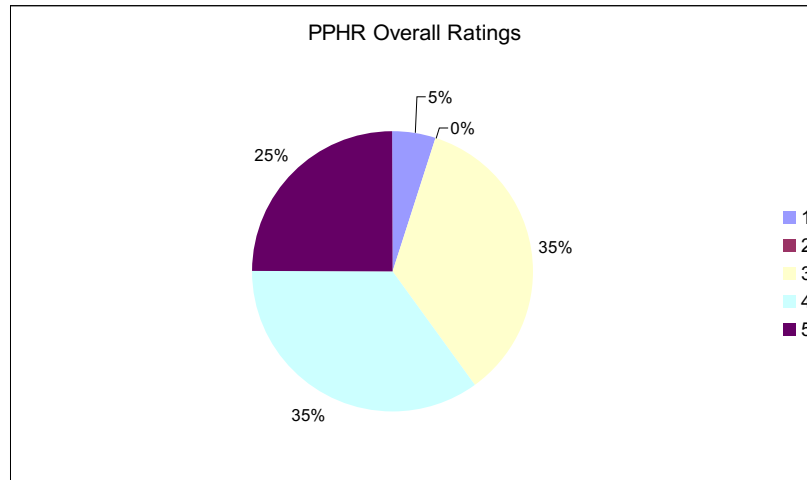
**Figure 3-31: Overall Ratings on Speed of Navigating Records (20 Participants)**



#### 3.6.4.4.6 PPHR Overall Ratings

Previous sections discussed ratings by overall participants on each feature of PPHR. This is a test for the result of PPHR overall ratings, as in ratings of overall satisfaction of PPHR in any sense. As mentioned earlier, the rating scale of the evaluation take 1 as terrible, 3 as OK and 5 as great. According to Figure 3-32, 25 % of participants think the PPHR is great while 35 % for each group of participants who think PPHR is OK and better than OK. There is one participant who thinks that the PPHR is terrible. Table 8 shows the data of overall satisfaction considering the age range and education level of participants; details will be discussed in the next section.

**Figure 3-32: PPHR Overall Ratings (20 Participants)**



**Table 8: Overall Satisfaction (Age and Education)**

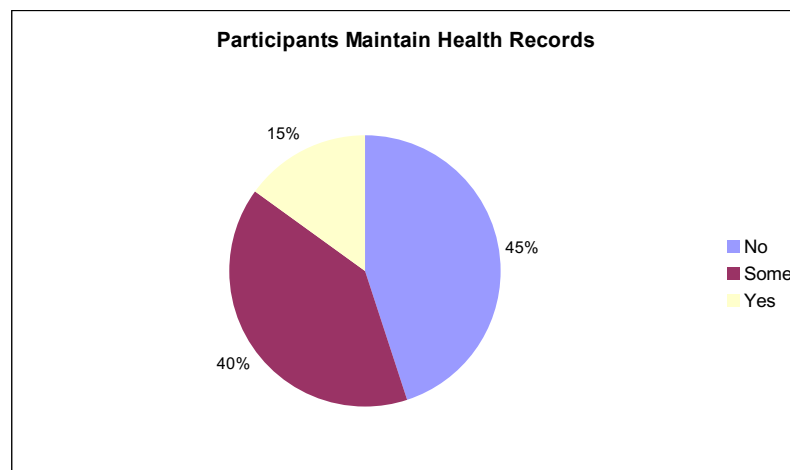
Number	Age Group	Education	Overall Satisfaction Rate
1	26-55	University	3
2	17-25	Secondary	5
3	1-16	Secondary	4
4	26-55	Secondary	4
5	56-100	Secondary	4
6	26-55	University	4
7	26-55	University	5
8	17-25	University	4
9	26-55	University	5
10	26-55	Secondary	4
11	56-100	Secondary	4
12	56-100	University	5
13	56-100	Secondary	3
14	17-25	Secondary	4
15	1-16	Secondary	3
16	26-55	University	4
17	56-100	Secondary	4
18	1-16	Secondary	3
19	17-25	University	3
20	1-16	Primary	1

#### 3.6.4.4.7 Before and After Using PPHR

The first question is to find out how many of the participants have been maintaining their own health records regardless of how they do it. Second question is to find out whether the participants will start using PPHR to maintain their own health records. These tests are to find out whether participants will be interested to use PPHR to maintain their health records after trying out the PPHR application. At the same time, the results also reflect the PPHR usefulness and acceptance as the better feedback gotten from this test, the greater chance that PPHR will be acceptable by most people.

Figure 3-33 shows the percentages of participants who did not or have been maintaining their own health records before using PPHR. Only 15 % of participants have been maintaining their own health records while 45 % of participants never maintain own health records. The big difference between participants who do and did not maintain health records portrays the neglect of personal health records importance by the residents in Malaysia. 40 % of them have been maintaining some of the health records, which mean that they still have a lot of health information which are not kept by them.

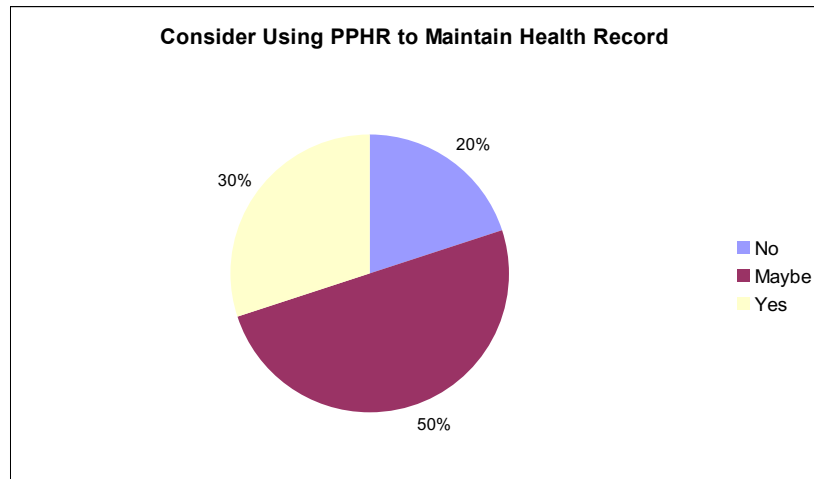
**Figure 3-33: Before Using PPHR (20 Participants)**



After using PPHR, participants who might use PPHR or consider using PPHR to maintain health records had increased. According to Figure 3-34, 30 % of the participants are willing to use PPHR as an application to maintain their health records which is more than the 20 % participants who do not want to use PPHR to maintain health records. 50 % of the participants may consider using the PPHR to maintain

health records. These tests show a great improvement of the amount of participants who changed their mind in maintaining health records with PPHR after using it.

**Figure 3-34: After Using PPHR (20 Participants)**



#### ***3.6.4.5 Comparing Overall Result Based on Age Group***

Comparing result based on age group is important as age can be related to personal life experiences, healthcare experiences and attentions paid on self-health. There is some negative feedback of overall ratings from the section above, and the reasons are unexplained. This section compares the overall result based on participants age group attribute and comparison between the results was done to check whether age group is a factor of deciding result of evaluation.

##### ***3.6.4.5.1 Participants Age Group Who Maintain Health Record***

The following diagram in Figure 3-35 compares the feedback from the participants based on age group to determine whether they maintain health record before using PPHR. Different age groups of people might have different views of the importance of maintaining health records, so this test finds out which age group of participants concern or know more about maintaining health records and which do not.

**Figure 3-35: Results of Participants Maintain Health Record Based on Age Group (20 Participants)**

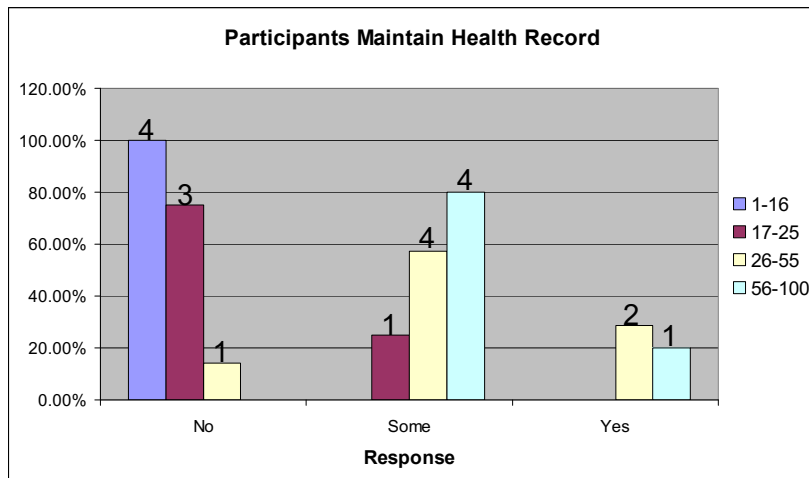


Figure 3-35 shows an obvious difference between the ratings done by different age group of participants. According to the diagram, none of the participants from the age group of 1-16 had ever maintained their own health records. As for the participants age group of 17-25, almost 80% of them have not been maintaining health records. Participants with age group of 26-55, less than 20% of them have not been maintaining health records, while none of the 56-100 age group participants have not been maintaining health records.

Most participants have been maintaining some but not all of the health records. As shown in Figure 3-35, 80% of the participants of age group 56-100 have been maintaining some of their health records, while 57% of 26-55 age group have been doing that. For the participants of 17-25 age group, only 25% of them do maintain some health records.

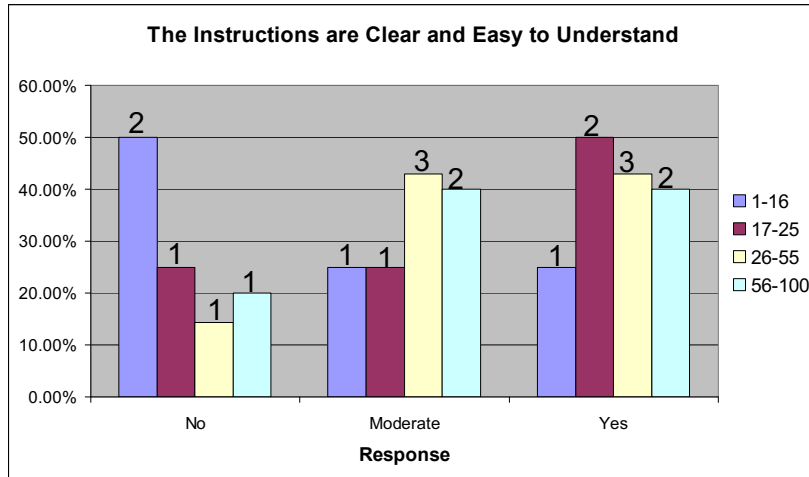
28% of 26-55 age group participants maintain a complete health records and only 20% of 56-100 age group participants have been doing that. This is an expected result because there are no popular services provided in Malaysia which help the patients to keep all the records, and also most of the records are not accessible or owned by the patients. Another reason might be caused by the low popularity of keeping personal health record in Malaysia, therefore there are not many technologies introduced to the patients to maintain their health records in an effective way.

As we can see from the result, it seems that participants of older age group are more concerned about maintaining their health records. As people grow older, there is an increased need to keep track of health status; this might be the reason why most participants in older age group have been maintaining health records. According to the verbal feedback from the participants of age group 17-25, most of them did not know the reason why they have to maintain their health data; they also have not much involvement with healthcare services too. None of the 1-16 age group participants have been maintaining their own health records this might be caused by the young age of participants, lack of sufficient knowledge of the importance of keeping track of own health data, or knowing the existence of health data. This could explain why there are as many as 45% of the participants (Figure 3-33) who have not been maintaining health records

#### 3.6.4.5.2 Instructions are clear and Easy to Understand Based on Age Group

According to the diagram in Figure 3-36, the ratings are quite evenly distributed between each age group. Age does not seem to be a factor which will influence the result of testing whether the PPHR instructions are clear and easy enough to understand. Since less than half of the participants think the PPHR instructions are too unclear and hard to understand, so the language structures and terms used in the PPHR must not be too hard. The understandings of the instructions might only be affected if the language standard of the participants is too low, and the language standard might be affected by age or education level. Test result based on education level will be inspected later in this document.

**Figure 3-36: Results of Participants Understand the PPHR Instructions Based on Age Group (20 Participants)**

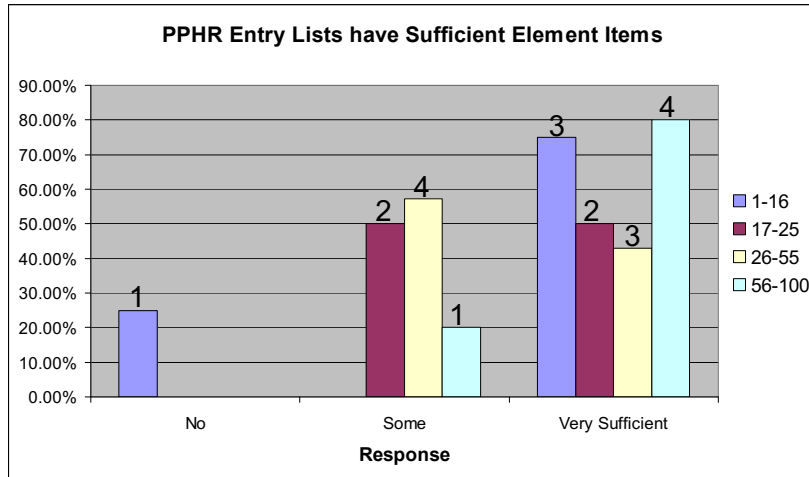


**3.6.4.5.3 PPHR Element Items Sufficiency Test Based on Age Group**

Figure 3-37 shows that only a small amount of participants of age group 1-16 think that the PPHR element items are seriously insufficient, while more than 70% of the rest of age group 1-16 participants think that PPHR entry lists have very sufficient element items. This means that the differences between these distributions are not affected by age. There are equally same numbers of participants who think that the PPHR lists have sufficient element items. According to the diagram, the majority of the age group 56-100 participants find that the element items provided are very sufficient, and the other 20% think that the element items are moderately sufficient. Participants who were satisfied with the tested PPHR feature are more than half, element items provided were claimed to be not sufficient enough might be caused by very rare medical situations which were neglected to be included in PPHR lists.



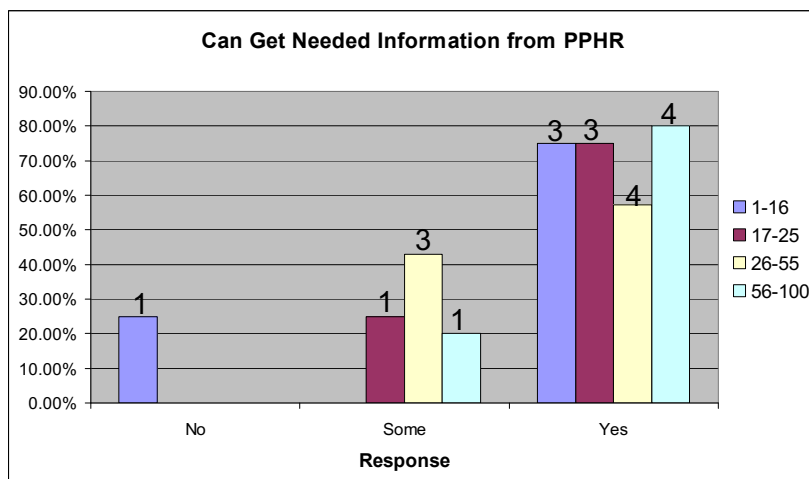
**Figure 3-37: Results of PPHR Element Items Sufficiency Based on Age Group (20 Participants)**



**3.6.4.5.4 PPHR Information Accessibility Based on Age Group**

In order to be able to obtain needed information from PPHR, the users should be familiar with commands of PPHR. Familiarity with the PPHR might be influenced by speed of learning and speed of learning might be affected by age differences. Although speed of learning might influence the familiarity, diagram in Figure 3-38 does not show that any particular age group finds it extremely hard to get information from the PPHR. Most of the participants in each age group can fully get information from PPHR.

**Figure 3-38: Results of the Ability to Find PPHR Records Based on Age Group (20 Participants)**

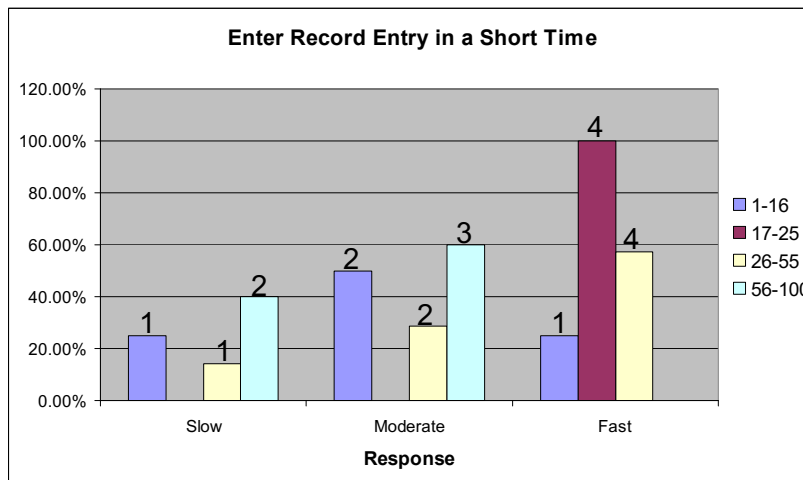


3.6.4.5.5 Enter Record Entry to PPHR Fast Based on Age Group

According to Figure 3-39, it seems that there are more than half of the participants of 17-25 and 26-55 age groups can enter record entry in a short time. People of these age groups are probably the people who basically involved most in cellphone technology compared to other age groups, because of the cellphone technology expansion in the last 15 years. In order to enter record entry in a short time, users need to be familiar with not only PPHR but cellphone too. So it is completely reasonable that majority of 17-25 and 26-55 age group participants can enter record entry in a short time. With the same reason, participants at the age group of 56-100 might not be as familiar with cellphone compared to the rest of the age groups.

The diagram shows that more than 50% of 1-16 and 56-100 age groups participants can enter record entry in a moderate or fast speed. This means that the PPHR usability of entering record entry is good enough to most of the participants of other age groups which are not influenced by the cellphone familiarity factor.

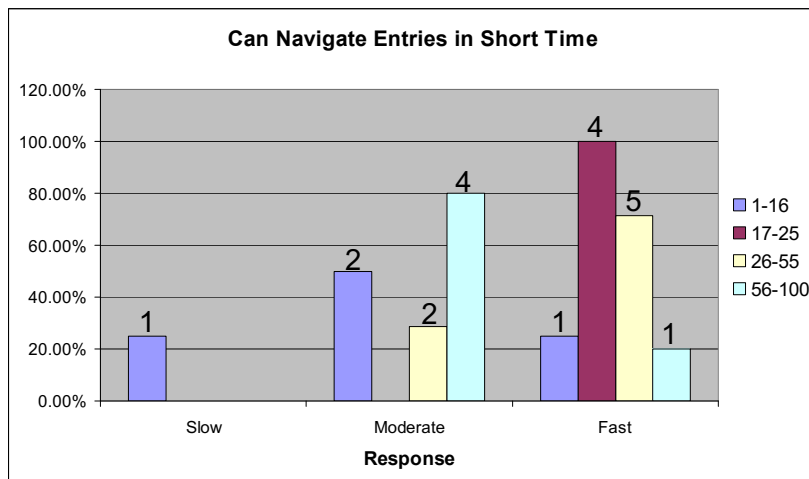
**Figure 3-39: Results of Enter Record Entry Speed Based on Age Group (20 Participants)**



3.6.4.5.6 Navigate Records Speed Based on Age Group

Like speed of entering record entry, speed of navigating records is based on the same factors as speed of entering record. As shown in Figure 3-40, 17-25 and 26-50 group age of participants can navigate the records in the shortest time while not many participants of 1-16 and 56-100 age groups participants can do that. Participants in most age groups think that time taken to navigate records is rather moderate or short. 56-100 age group participants mostly took moderate time period to navigate a record.

**Figure 3-40: Results of Navigating Records Fast Based on Age Group (20 Participants)**

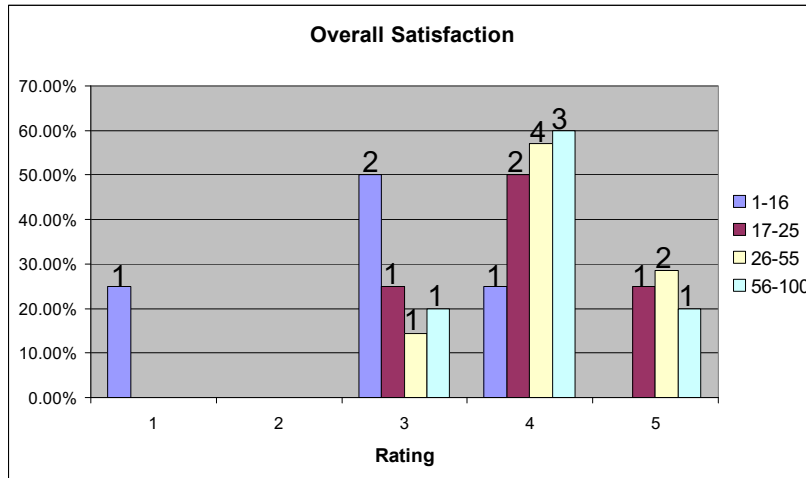


### 3.6.4.5.7 PPHR Overall Satisfaction Ratings Based on Age Group

PPHR commands and usability ratings were done to find out what participants think of PPHR in specific features. This overall satisfaction test is to find out the overall satisfaction of participants towards the PPHR. Although different ratings might be given for all the other questions, there are no direct answers about whether they are satisfied with what PPHR can do for them in overall.

Figure 3-41 shows a diagram with overall satisfaction ratings based on age group. Except for 25% of the 1-16 age group participants, the PPHR satisfaction ratings of the rest of the participants are above average. There are more 1-16 age group rated OK than Better than OK, but none of them give a rating of Great. As for 26-55 and 56-100 age groups participants, majority of them rated Better than OK and the numbers of participants of 56-100 age group gave a rating of OK and Great are equally the same.

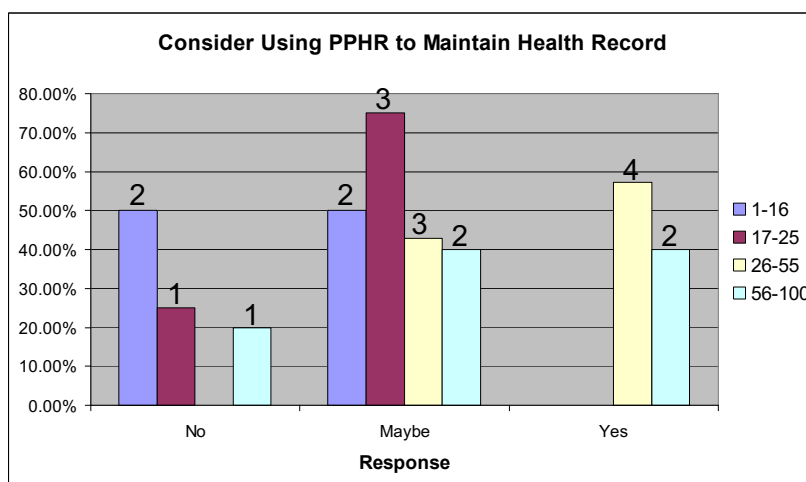
**Figure 3-41: Results of PPHR Overall Satisfaction Based on Age Group (20 Participants)**



**3.6.4.5.8 Consider Using PPHR to Maintain Health Record Based on Age Group**

Compared to Figure 3-35 in Section 3.6.4.5.1, diagram in Figure 3-42 shows a significant increase in participants who will definitely or consider using a PPHR to maintain their health records. The result of this test might be affected by age group, only the 1-16 age group does not show as much increase as other age groups. This may be caused by the participants of that age group being too young to have knowledge about health data and the importance of maintaining it. Other than that, education level for 1-16 age group participants might face difficulties understanding PPHR.

**Figure 3-42: Results of Considering Using PPHR Based on Age Group (20 Participants)**



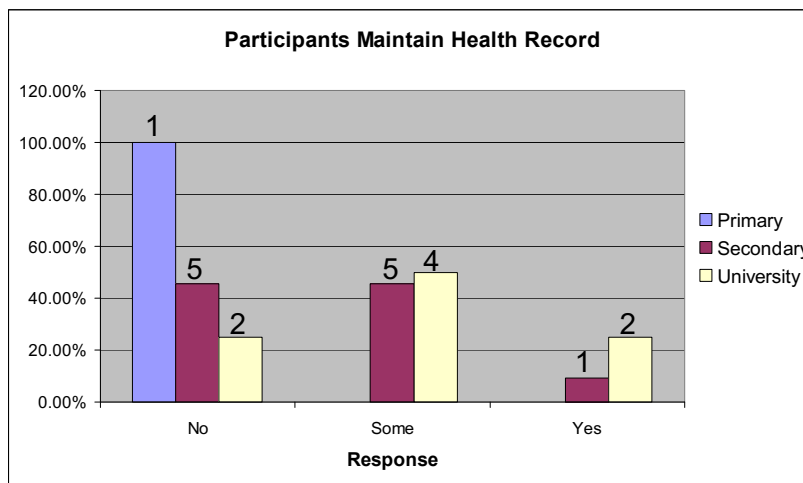
**3.6.4.6 Comparing Overall Result Based on Education Level**

Education level may influence the speed of learning and the understandings of PPHR instructions. This section compares the overall result based on participants education level attribute. Comparisons between the results were done to check whether education level is a factor of deciding result of PPHR evaluation. Education levels are divided into three levels, Primary, Secondary and University.

**3.6.4.6.1 Participants with different education levels who maintain health record**

According to Figure 3-43, all of the primary school graduates have not been maintaining health records. Among all the participants, all the primary school graduates are in the age group of 1-16, so the reason of not maintaining health records might be the same. Most secondary and university level participants do maintain some of the health records. Very few of secondary level participants maintain a complete health record.

**Figure 3-43: Results of Participants Maintain Health Record Based on Education Level (20 Participants)**

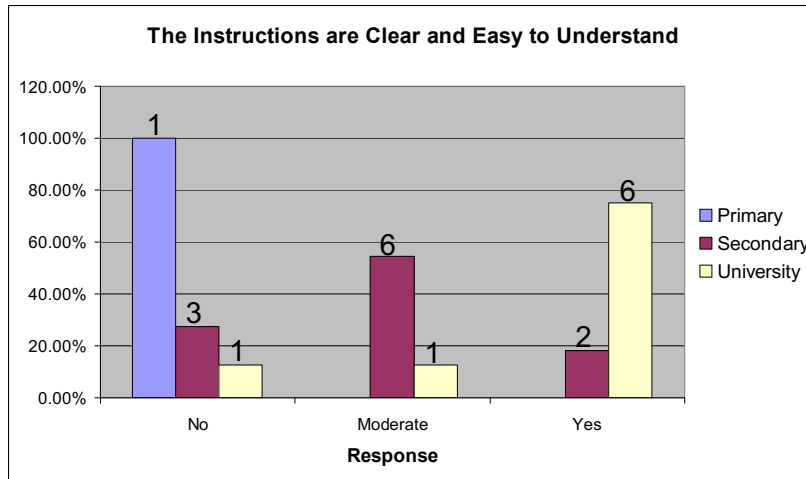


**3.6.4.6.2 Results of Participants Understand the PPHR Instructions Based on Education Level**

Figure 3-44 shows an obvious result that participants with primary education level cannot easily understand the instructions clearly. Most university level participants can fully understand the instructions, but there are still some participants with university level who do not understand the instructions at all or only understand some of them. As for secondary education levels, less than 20% of them fully understand the instructions. There are also secondary level participants who do not understand the instructions at all but majority of them understand some instructions. Primary education level

participants do not understand the instructions this might be caused by the lower level of education in primary school.

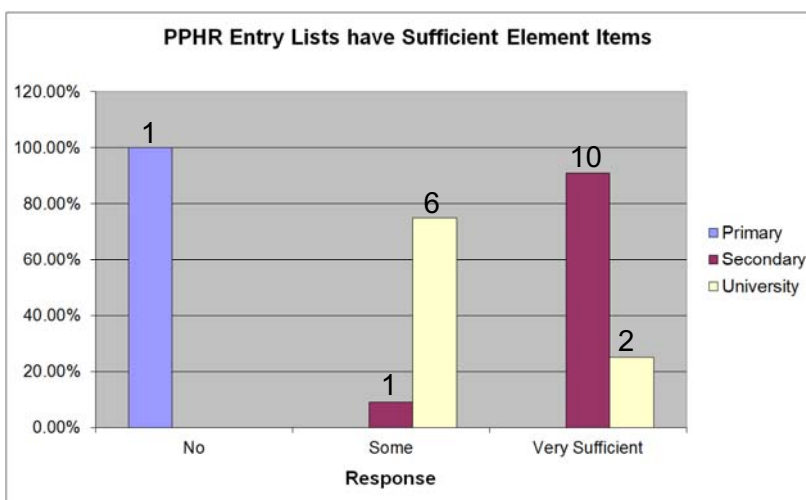
**Figure 3-44: Results of Participants Understand the PPHR Instructions Based on Education Level (20 Participants)**



3.6.4.6.3 PPHR Element Items Sufficiency Test Based on Education Level

As shown in Figure 3-45, none of the primary education level participants think that PPHR entry lists have sufficient element items. Most of the university level participants think that PPHR entry list only have some element items, but only a few secondary level participants feel that way. Most secondary level participants gave very high ratings on PPHR element items sufficiency, 90% of them think that PPHR element items are very sufficient.

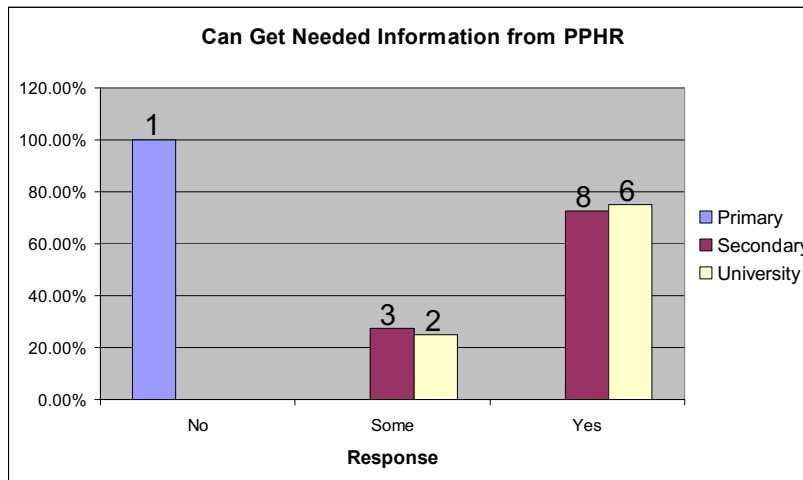
**Figure 3-45: Results of PPHR Element Items Sufficiency Based on Education Level (20 Participants)**



3.6.4.6.4 PPHR Information Accessibility Based on Education Level

For the same reasons in the other tests based on education level, participants with primary education level cannot get needed information from PPHR. As shown in Figure 3-46, more than 70% of the university and secondary level participants can get all needed information. There are participants with secondary and university level who can only get some of the needed information from PPHR.

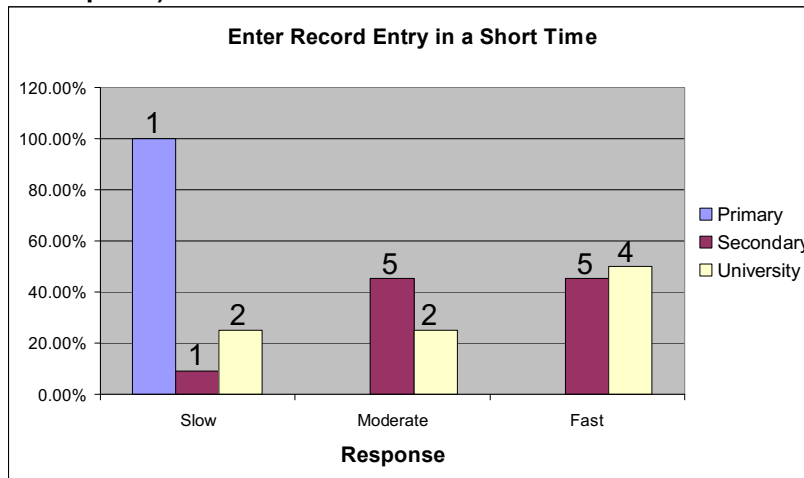
**Figure 3-46: Results of the Ability to Find PPHR Records Based on Education Level (20 Participants)**



3.6.4.6.5 Enter Record Entry to PPHR Fast Based on Education Level

Figure 3-47 shows that participants with primary education level consumed a long time to enter a record entry, while a lower percentage of secondary level participants are slow in entering a record entry. However speed of entering record entry does not seem to differ much among participants with secondary or university education level.

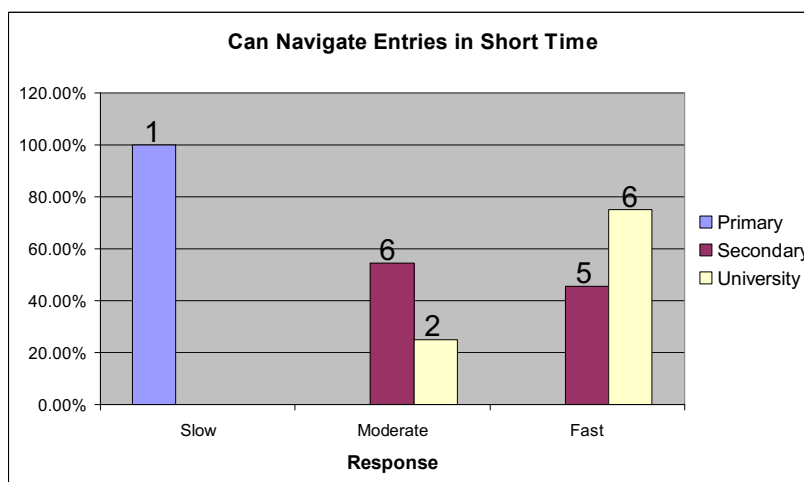
**Figure 3-47: Results of Enter Record Entry Speed Based on Education Level (20 Participants)**



**3.6.4.6.6 Navigate Records Speed Based on Education Level**

Navigation speed may depend on the familiarity and understanding of the PPHR. The diagram below shows that primary level participants are very slow in navigating records. However, more than 50% of secondary level participants can do record navigation in a moderate speed while the rest can do it in a very short time. As for the university level participants, there are more than 70% of them can navigate records fast, and only around 25% of them used moderate time period to navigate records.

**Figure 3-48: Results of Navigating Records Fast Based on Education Level (20 Participants)**

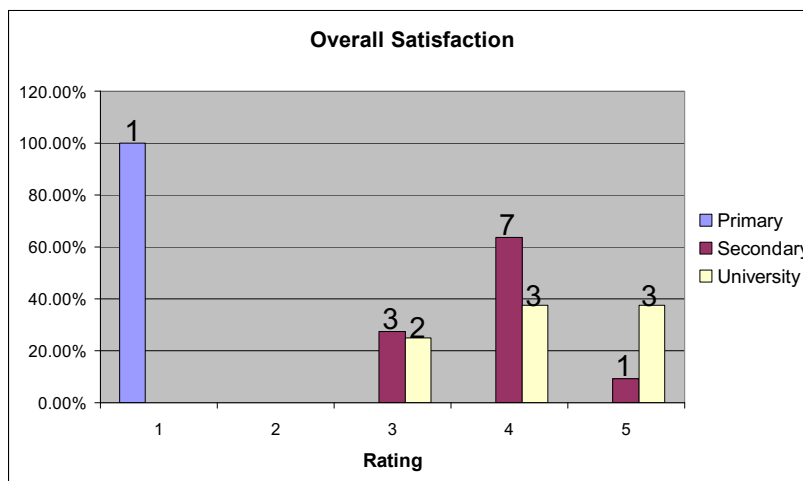




3.6.4.6.7 PPHR Overall Satisfaction Ratings Based on Education Level

According to Figure 3-49, participants with primary education level are not satisfied with PPHR at all. More than 60% of secondary education level participants are quite satisfied with PPHR and gave overall satisfaction a rating of 4. Around 27% of secondary education level participants gave rating of 3 and the other 9% gave rating of 5. Like the result of PPHR overall satisfaction based on age group, only a small number of participants gave a rating of 1, and all the other participants gave ratings above average. There are more than 30% of the university education level participants are quite satisfied with PPHR, and also the same amount of university education level participants think that the PPHR overall satisfaction is great. The rest of the university education level participants gave the satisfaction rating of 3 which is OK.

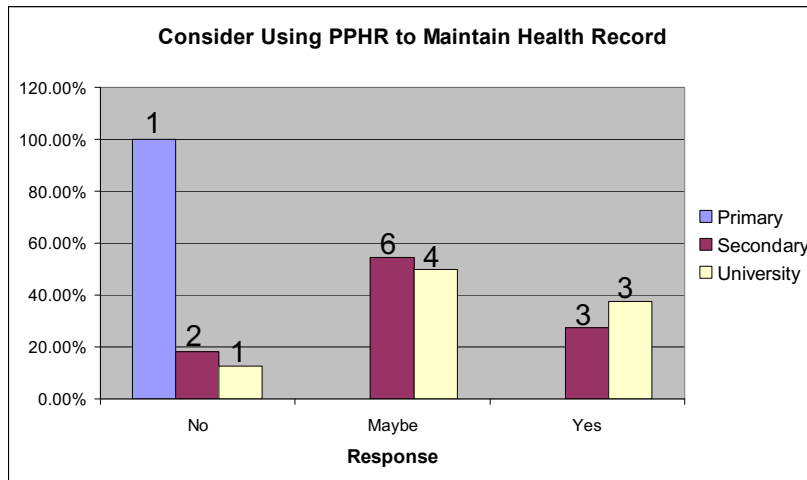
**Figure 3-49: Results of PPHR Overall Satisfaction Based on Education Level (20 Participants)**



3.6.4.6.8 Consider Using PPHR to Maintain Health Record Based on Education Level

This test is to check whether consideration of using PPHR to maintain health record will depend on education level. According to Figure 3-50, primary education level participants chose not to use PPHR to maintain health record, less than 20% of secondary and university education level participants refuse to try maintaining the PPHR. More than 50% of secondary level participants will consider using PPHR to maintain their health records and around another 25% who will definitely use PPHR. As for university level participants, most of them will consider trying out PPHR to maintain health records. Almost 40% of university level participants want to use PPHR, and those who do not want to use PPHR to maintain their health records are less than 20%.

**Figure 3-50: Results of Considering Using PPHR Based on Education Level (20 Participants)**



#### *3.6.4.7 Comparing Understandings of PPHR Instructions Based on Native and Non-native Language*

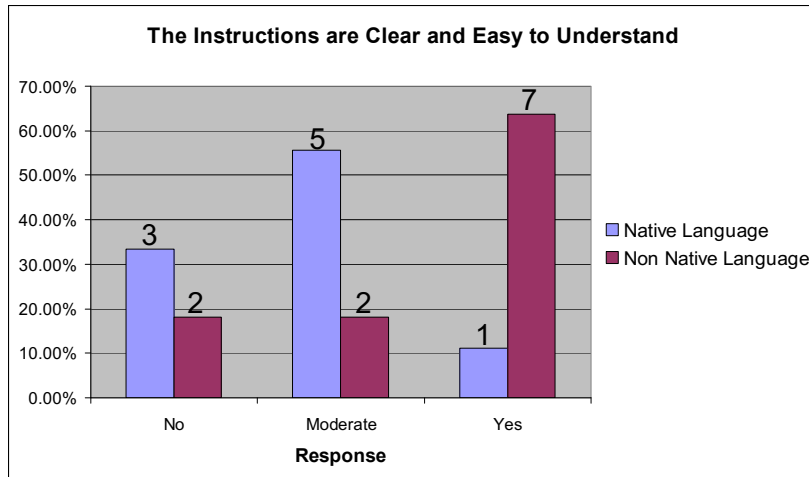
PPHR can be presented in four different languages however there are no native languages for Indian and Iban. Participants in the evaluation included both Indian and Iban, and the chosen language of these participants must be one of the four available ones. Besides that, some participants whose native language is available on the PPHR did not choose it. This is a great chance to test whether the provided instructions in different languages are simple and clear enough to understand, as most peoples first language is their native language, followed by the others. If majority of participants can still understand the PPHR instructions clearly with non-native language, it might signify that the PPHR terms in different languages are simple and clear.

The only question related to this test is The instructions are clear and easy to understand . This comparison is based on participants who use their own native language or other language. This test is to find out whether there is a significant difference between understanding of PPHR instructions among participants who use their native language and non-native language.

Figure 3-51 shows that more than half of the participants who used non-native language can clearly understand the PPHR instructions easily, while of those who used native language only 11% thought the instructions are clear and easy to understand.

Less than 20% of the participants who used non-native language found it hard to understand the instructions, and the other 20% think the instructions are moderately clear and easy to understand.

**Figure 3-51: Results of Participants Understand the PPHR Instructions Based on Native and Non-native Language (20 Participants)**



#### **3.6.4.8 Evaluation Conclusions**

Malaysia is a multicultural and multiracial country which most of the residents speak at least 2 to 3 languages including dialects. It is important to include as many races in the PPHR evaluation in order to obtain a more representative result. Besides that, participants with different age groups and education levels were also encouraged to take part in the PPHR evaluation.

According to the results from above sections, it can be seen that most of the results are above average ratings. In the PPHR evaluation ratings scale, ratings above average means ratings are OK or Better than OK or Great. For the negative feedbacks of the results, factors which might decide the ratings were used to compare, such as age group and education level. Sections 3.6.4.5 and 3.6.4.6 show constant negative feedbacks from participants of 1-16 age group or primary education level. These two factors are somehow related as Table 3 shows that there is a participant who is in the age group of 1-16 and is having primary education level. One of the limitations of this evaluation is the difficulty to find a young age participant who is willing to spend 4 days learning PPHR usages and then filling up the evaluation form. Only one primary education level user within the age group of 1-16 participated in the evaluation, the factors of leading to the negative feedbacks are unclear, only if there are more participants of the same type. Since the other 1-16 age group participants who have

secondary education level did not give as much negative feedbacks, we can assume that the PPHR is somehow too complicated for primary education level users.

Figure 3-51 from previous section about comparison between understandings of PPHR using native language and non-native language proved that the terms and the language structures in four different languages are clear and easy to understand. Other than that, there are no complaints found from the comments of PPHR commands (refer Tables 5, 6, 7 and 8). This means that language choosing feature in PPHR is good and useful.

When comparing evaluation results based on age group, the readings reflect that the participants of 16-25 and 26-55 age groups seem to be able to operate PPHR better in the sense of speed. Although the older participants of 55-100 age group cannot navigate or enter entry as fast, their speeds are not below average, which is acceptable for PPHR usability test. The other important finding is that after trying out the PPHR for 4 to 5 days, there is a significant increase of participants who may consider or already decide to use PPHR to maintain their health records.

## Discussion

In the Introduction we discussed the need for a Portable Personal Health Records (PPHR), especially in developing countries which lack Hospital Information Systems and other possibilities for digital storage and communication of health records. In the Methods chapter we discussed the requirements, design, implementation and evaluation of a PPHR for cellphones. In the Results chapter we described the PPHR product and the outcome of the evaluation tests.

Here we will compare the PPHR with other, similar initiatives and with international standards related to this type of health record. Then we will discuss unfinished business and potential further work.

### 4.1 Comparison of the PPHR with Other Initiatives

The PPHR is not the only project involving remote data collection for health records. Here we describe some others and compare them with the PPHR.

Table 9: List of Features and Functions of PPHR and the Other Initiatives

	PPHR	JavaRosa	Sana	Handy Sana 210 – Heart Suite	AirStrip	ffEHR
URL	<a href="http://code.google.com/a/eclipselabs.org/p/hmapper/">http://code.google.com/a/eclipselabs.org/p/hmapper/</a>	<a href="http://www.openrosa.org/">http://www.openrosa.org/</a>	<a href="http://www.sanabobile.org/">http://www.sanabobile.org/</a>	<a href="http://handysana.com">http://handysana.com</a>	<a href="http://www.airstrip.tech.com">http://www.airstrip.tech.com</a>	<a href="http://trac.afterfive.tech.com/ffehr/">http://trac.afterfive.tech.com/ffehr/</a>
Developer	-	Open Rosa	Sana Team	Medical Marketing Berlin	AirStrip Technologies	Freefeathers
Purpose	Store individual HR locally, backup to PPHR (Google Health)	Collect data remotely, store on central server	Collect data remotely, send to central server for medical review, diagnosis, plan of care	Store health data locally, send to central server for monitoring or analysis	Allows data to be accessed on smart phones or tablets remotely	Store individual HR in local WWW browser
Platform	J2ME	J2ME	Java on Android OS	Java on Android OS	Microsoft.NET Framework	Mozilla Programming Framework
Input	List, graphic regions selections	XForms definitions, user enter data into forms in mobile phone	text, selections, images, videos, audios	Sensors, image, text, selections	N/A	Forms

Local storage	yes	no	yes	no	no	no
Transmission channel	SMS	GPRS / broadband	GPRS, Wi-Fi	GPRS, Wi-Fi	GPRS, Wi-Fi, SMS and USB cable depending on the size and quality of data	GPRS / broadband / Wi-Fi
Transmission format	Plain text	HL7 v2.x	N/A	N/A	HTML (get/post)	HL7 / XML

**Compatibility** In order to ensure maximum compatibility of PPHR with cellphones, we used J2ME which is the most widespread language on older phones. There are still many people in Malaysia, including people in rural areas, who are using old phones. PPHR and JavaRosa are using J2ME and the others do not.

**Availability** Records stored on phone storage can increase the availability of records as mobile phones will usually be wherever the owner is. PPHR and Handy Sana 210 store records on local storage, which means that users are able to carry their health records anywhere as long as the cellphone, which has the PPHR installed in it, is with them.

**Communications** As mentioned in Section 2.2.2, GSM covers the widest area not only in Malaysia but also in the rest of the world. For maximum usage of data transmission, GSM is very important especially for many rural areas in Malaysia which do not support other communication channels. PPHR uses GSM to back up data, while the other initiatives use GPRS, broadband or others. PPHR uses ICPC2e as base vocabulary. This can be rather easily translated to CCR message format (See Section 1.7.2.2).



## 4.2 PPHR and International Standards for Health Records

### 4.2.1 ISO 18308 - Requirements for an Electronic Health Record Architecture

Features of the developed PPHR are compared with ISO/TS 18308 requirements (International Organization for Standardization, 2004). The PPHR shall meet as many of the ISO/TS 18308 requirements as possible.

**Table 9: Comparing on PPHR meeting ISO 18308 requirements**

	5.1 STR 1 STRUCTURE	PPHR
	5.1.2 Record organisation	
STR1.1	The EHRA shall enable information in the EHR to be organised in different sections allowing navigation by users and views of sections to be returned as the result of queries.	Record Visualization
STR1.2	The EHRA shall ensure that the format of the EHR as it appears to the clinician or user is able to conform to specifications set by standards organisations, regulatory and accreditation agencies, professional groups, local healthcare institutions and users.	Uses ICPC2e as the base vocabulary, can be converted to CCR (ASTM E2369-05)
STR1.3	The EHRA shall support an EHR which can be conveyed among EHR users and merged with other EHR information independently of hardware, software (application programs, operating systems, programming languages), databases, networks, coding systems, and natural languages.	The CCR translation will fulfils this role
STR1.4	The EHRA shall enable information in the EHR to be organised and retrieved in a manner that facilitates its secondary uses.	Allows searching for Problems, date ranges, keywords
STR1.5	The EHRA shall support archiving.	No
	5.1.3 Data organisation	
STR2.1	The EHRA shall enable storage of data as lists such that the order of the data is preserved when the data is displayed.	Entries are stored in strictly chronological order
STR2.2	The EHRA shall enable storage of data in tables such that the relationships of the data with the row and column headings are preserved.	No item for this
STR2.3	The EHRA shall enable storage of data in hierarchies such that the relationship between the node parents and children are preserved.	YES, e.g. Problem>hand> .> .

STR2.4	The EHRA shall enable storage of data such that simple name / value pairing is preserved.	Yes
STR2.5	The EHRA shall enable the storage of multiple values of the same measurement taken at closely proximate times at the same contact, or at different contacts and at different locations. The context of these measurements shall be preserved such as who took the measurement, what method was used etc. These values should be able to be returned in a query and ordered in different ways.	This can only be done via manual entry of information
STR2.6	The EHRA shall support the inclusion of narrative free text.	Yes
STR2.7	The EHRA shall support searching within non-structured data (text and non-text) and the inclusion of structured text within this data.	Searching with keywords
STR2.8	The EHRA shall support the inclusion of comments within the data stored enabling the clinician to qualify structured information appropriately. Comments shall be able to be linked to specific data attributes.	Each new entry allows free text input
STR2.9	The EHRA shall provide a means for different levels of emphasis to be associated with comments and other entries this may alter the way they are displayed or their returning in a query.	No item for this

STR2.10	<p>The EHRA shall provide for the recording, storage and retrieval of comprehensive information about patient care. The EHRA shall at a minimum allow for the recording, storage and retrieval of all structured and unstructured data on:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Patient history _____</li> <li><input type="checkbox"/> Physical examination _____</li> <li><input type="checkbox"/> Psychological, social, environmental, family, and self-care information _____</li> <li><input type="checkbox"/> Allergies and other therapeutic precautions _____</li> <li><input type="checkbox"/> Preventative and wellness measures such as vaccinations and lifestyle interventions _____</li> <li><input type="checkbox"/> Diagnostic tests and the therapeutic interventions such as medications and procedures _____</li> <li><input type="checkbox"/> Clinical observations, interpretations, decisions, and clinical reasoning _____</li> <li><input type="checkbox"/> Requests/orders for further investigation, treatments, or discharge _____</li> <li><input type="checkbox"/> Problems, diagnoses, issues, conditions, preferences and expectations _____</li> <li><input type="checkbox"/> Healthcare plans, health and functional status, and health summaries _____</li> <li><input type="checkbox"/> Disclosures and consents _____</li> <li><input type="checkbox"/> Suppliers, model and manufacturer of devices (e.g. implants or prostheses). _____</li> </ul>	<p>Yes Yes Yes Yes Yes Yes Yes No Yes Functional status No Medical equipment</p>
STR2.11	The EHRA shall support the recording (and classifying for identification purposes) of patient identification, location, demographic, contact, employment and other administrative data.	Yes
STR2.12	The EHRA shall support standards for information which enable the unambiguous identification of the subject of care, the clinicians involved in care (including their role and context of care), the location of care, the date/time and duration of care, and third parties such as next of kin and non-clinical contacts.	Identification of PPHR owner
STR2.13	The EHRA shall support the administration of healthcare processes and episodes of care as well as the organisation of visit and encounter data.	No item for this
STR2.14	The EHRA shall support the recording of financial and other commercial information such as health plan enrolment, eligibility and coverage information, guarantor, costs, charges, and utilisation.	No item for this

STR2.15	The EHRA shall support the recording of legal status and consents relevant to the patient's healthcare (e.g. legal status of guardianship order, consents for operations and other procedures).	No item for this
STR2.16	The EHRA shall be amenable to querying for the purpose of data aggregation to support information gathering required for population and public health initiatives, surveillance, and reporting.	PPHR can be backed up to online database, which can be used for data aggregation
	5.1.4 Type and form of data	
STR3.1	Numeric and quantifiable data The EHRA shall support the definition of the logical structure of numeric and quantifiable data, including the handling of units.	Yes, with manual entry
STR3.2	Quantities should include a measure of precision related to the method of measurement.	Only with manual entry
STR3.3	Percentages shall be able to be expressed as quantities.	Not applicable
STR3.4	Quantity ranges The EHRA shall support the definition of the logical structure of ranges that is high and low values.	Only with manual entry
STR3.5	Quantity ratios The EHRA shall support the definition of the logical structure of quantity ratios (i.e. x of per y of b).	Not applicable
STR3.6	Dates and times The EHRA shall support the definition of the logical structure of dates and times.	PPHR uses the XML date-time format
STR3.7	The EHRA shall support approximate, partial, and fuzzy dates and times such as: <input type="checkbox"/> <input type="checkbox"/> approximate dates/times: e.g. sometime yesterday, last week; <input type="checkbox"/> <input type="checkbox"/> partial dates: e.g. ??/May/1997, /??/1928.	No item for this

STR3.8	The EHRA shall support the recording of future planned events or actions such as: <ul style="list-style-type: none"> <li><input type="checkbox"/> periods of day or time: e.g. morning, afternoon, evening, shifts (AM, PM, Nocte), while awake;</li> <li><input type="checkbox"/> Approximate points of date/time: e.g. upon awakening, at mealtime (breakfast, lunch, dinner), at bed time;</li> <li><input type="checkbox"/> relative points of day or time: e.g. before breakfast, after lunch, before bedtime, two days post discharge ,one week after last dose;</li> <li><input type="checkbox"/> Alternating and patterned dates/times: e.g. alternate every 8 hours, alternate every 3 days, every Monday/Wednesday/Friday, every Sunday, every third Tuesday.</li> </ul>	No item for this
STR3.9	The EHRA shall support the recording of time at a given instant, an elapsed time since a particular event, and as a duration.	Time of entry is automatically recorded, others are a manual option
STR3.10	The EHRA shall support the recording of the time-zone in which the recording took place.	No item for this
STR3.11	The EHRA shall support recording of time in all units down to milliseconds.	milliseconds are not included
STR3.12	The EHRA shall allow for the incorporation of data types defined elsewhere, such as DICOM, MIME, and ECG.	No item for this
STR3.13	The EHRA shall support the recording of references such as normal ranges and the attributes and context relevant to a particular observation or measurement.	Can be manually recorded
STR3.14	The EHRA shall support the recording of contextual data associated with the date/time the event occurred.	Can be manually recorded
STR3.15	The EHRA shall support the recording of contextual data associated with the date/time the event was committed to the record.	Can be manually recorded
STR3.16	The EHRA shall support the recording of contextual data associated with the subject.	Can be manually recorded
STR3.17	The EHRA shall support the recording of contextual data associated with the person responsible for recording and committing the event.	No item for this
STR3.18	The EHRA shall support the recording of contextual data associated with the healthcare facility.	No item for this

STR3.19	The EHRA shall support the recording of contextual data associated with the location where the event was recorded.	Planned for a future version
STR3.20	The EHRA shall support the recording of contextual data associated with the reason for recording the information associated with the event.	No item for this
STR3.21	The EHRA shall support the recording of contextual data associated with the protocol associated with the information recorded.	No item for this
STR3.22	The EHRA shall define the semantic representation of links between different information in the EHR.	No item for this
STR3.23	The EHRA shall support links to externally referenced data' which is not able to be stored within the EHR, providing patient safety is not compromised.	No item for this
	5.1.5 Supporting health concept representation	
STR4.1	The EHRA shall support multiple coding systems (entry or interface terminologies, reference terminologies and classifications) by providing for interfaces with electronic tools such as terminology browsers, terminology editors and terminology servers.	No item for this
STR4.2	At the data attribute level, the EHRA shall support the capture of the code, the coding scheme (e.g., coding/classification system), version, original language, and original rubric	Only ICPC2e is used
STR4.3	The EHRA shall enable storage of data from terminologies and preserve the information about the terminology set from which it was chosen.	No item for this
STR4.4	Where information is not represented uniquely in only one place and one way, the EHRA shall support explicit rules to avoid ambiguity (e.g. it must be clear what [not] [pedal pulses absent] means).	Encoding to SNOMED-CT or LOINC or ICD-10 will be in the message gateway, not on the cellphone
STR4.5	The EHRA shall support a means of mapping between objects in information and inference models corresponding to a well-defined set of concepts in the foundation reference terminology or concept model.	No item for this

STR4.6	The original textual representation as entered by the clinician shall be retained in the HER when information is translated from one natural language to another or when terms are mapped from one coding/classification system to another.	Yes
	5.2 PRO 2 PROCESS	
	5.2.2 Clinical processes	
PRO1.5	The EHRA shall support the recording and presentation of holistic health status, functional status, problems, conditions, environmental circumstances and issues.	Can be manually recorded
PRO1.6	The EHRA shall allow the recording and presentation of data in a problem-oriented structure including problem status, resolution plans and targets (problem-oriented here includes conditions and issues). Note that the EHRA should also allow other structures such as chronologically-oriented, episode-oriented, workflow-oriented, and process-oriented structures.	Yes, allows for searches on Problems and the dates around them; also allows chronological listing
PRO1.7	The EHRA shall support a patient's lifetime, longitudinal record of health status and care interventions which can be viewed as a chronological health record. The patient HER is at once (simultaneously): retrospective: an historical view of health status and interventions (e.g., completed health service events/acts); concurrent: a now view of health status and active interventions (e.g., health service events/acts now underway); and prospective: a future view of planned interventions (e.g., health service events/acts scheduled or pending).	PPHR is a chronological, retrospective record.
PRO1.8	The EHRA shall support the recording of the clinical reasoning (including reasoning by automated processes) for all diagnoses, conclusions, and actions regarding the care of a patient.	Can be manually recorded

PRO1.9	The EHRA shall support the automatic presentation of warnings, alerts and reminders such as patient infective status, allergies and other therapeutic precautions, outstanding interventions, and urgent results.	Not included
PRO1.13	The EHRA shall support care planning, including the management of process states (e.g. planned, ordered, scheduled, in progress, on hold, pending, completed, amended, verified, cancelled), within the care planning process.	Not intended for management functions
PRO2.3	The EHRA shall support the ability to review information of all types recorded in the past, including via the use of query and filter facilities, during the data capture process.	Yes
PRO2.4	The EHRA shall support selective retrieval and customized views of the same information for specific needs (e.g. decision support, data analysis).	Allows searches for Problems, date ranges, keywords
	5.3 COM 3 COMMUNICATION	
	5.3.2 Messaging	
COM1.1	The EHRA shall support the export and import of data received using messaging protocols such as HL7, UN/EDIFACT and DICOM.	Exports data as name-value pairs which can be converted to CCR standard format
	5.3.3 Record exchange	
COM2.1	The EHRA shall allow for the exchange of a complete EHR or a part of an EHR (an extract) between EHRA compliant systems.	Planned for a future version
COM2.2	The EHRA shall support serialisation of data for interoperability purposes (e.g. via XML, SOAP, CORBA, .Net etc).	Exports data as name-value pairs which can be converted to CCR standard format
COM2.3	The EHRA shall define the semantics of merging data from an EHR extract with the EHR resident in the receiving system.	No item for this
COM2.4	The EHRA shall provide an audit trail of exchange processes, including authentication, to enable identification of points of EHR extract transmittal and receipt. This needs to account for merging processes.	No item for this



COM2.5	The rules covering the exchange of an extract consisting of the current state of part or all of the record shall be the same as those for exchanging the complete record.	No item for this
COM2.6	The EHRA shall enable semantic interoperability of clinical concepts between EHR systems to support automatic processing of data at the receiving system.	Planned for a future version
	5.4 PRS 4 PRIVACY AND SECURITY	
	5.4.2 Privacy and confidentiality	
PRS1.1	The EHRA shall support the application of prevailing privacy and confidentiality rules.	Those which apply to cellphones and cellphone applications
	5.4.3 Consent	
PRS2.1	The EHRA shall support recording of informed consent for the creation of a record.	Installation of the PPHR package and creation of a record are voluntary
	5.7 COC 7 CONSUMER/CULTURAL	
	5.7.2 Consumer issues	
COC1.1	The EHRA shall support the production of a consumer oriented view.	No item for this
COC1.2	The EHRA shall support consumers' right of access to all EHR information subject to jurisdictional constraints.	The consumer is the owner and maintainer of the PPHR
COC1.3	The EHRA shall support consumers being able to incorporate self-care information, their point of view on personal healthcare issues, levels of satisfaction, expectations and comments they wish to record in EHRs.	YES this is a main purpose of the PPHR
	5.7.3 Cultural issues	
COC2.1	The EHRA shall support interoperability in away that is truly global, yet respects local customs and culture. It follows that the process shall be both simple and amenable to customization in different jurisdictions.	Not confirmed whether it is global yet. Yes for Malaysia

### **4.2.2 ICPC2e - International Classification for Primary Care, 2e**

The PPHR vocabulary is based on the ICPC2e version 4 (WONCA 2010), as described in Section 2.5.4. However, because of necessity there had to be some changes and additions. Although this breaks the adherence to the standard, it can be explained and justified. Although ICPC2e is designed for primary care, its target audience is primary caregivers, i.e., medically trained personnel who work in primary care. So its terminology is familiar to those people. Some of the terms had to be simplified to make them comprehensible to ordinary people. ICPC2e does not include demographic fields or plain notes. We feel that the latter are necessary for health-related information which may not fit neatly into any category. It also does not include medical equipment, a term which we adopted from the CCR or social history, and a health factor which has become increasingly recognized in recent years.

### **4.2.3 Other PPHR Terms**

Table 11 lists all the PPHR terms which are not included in ICPC2e - types of terms including medical devices, medications, conditions, results, procedures, lab blood test and urine test. In some cases the terms appear in ICPC2e under different categories.

**Table 11: Added PPHR Terms**

<b>Added Terms</b>	<b>Type</b>
Blood type	Alert
Glucose	LAB Blood
Cholesterol	LAB Blood
HDL	LAB Blood
LDL	LAB Blood
Creatinine	LAB Blood
Glucose	LAB Urine
pH	LAB Urine
Nitrite	LAB Urine
Protein	LAB Urine
Ketones	LAB Urine
Pacemaker	Medical Devices
Hearing aid	Medical Devices
False teeth	Medical Devices
Glasses-contact lens	Medical Devices
Wheelchair	Medical Devices
Crutches	Medical Devices
Pill	Medication
Capsule	Medication
Powder	Medication
Injection	Medication
Creme	Medication
Patch	Medication

Suppository	Medication
poor circulation	New entry for Blood
SpO2	New entry for Body Sign
Itching	New entry for Skin
Finger-toe nail	New entry for Skin
Notes	New entry to extra information
Surname	Person
Given names	Person
Date of Birth	Person
ID number	Person
ID issuer	Person
Gender	Person
Address	Person
Longitude	Person
Latitude	Person
Phone	Person
Email	Person
Ethnicity	Person
Language	Preferred language
Blood	Result
Urine	Result
Stool	Result
Biopsy	Result
ECG	Result

Vision	Result
Hearing	Result
Allergy	Result
Stress	Result
Endoscope	Result
EEG	Result
Home life-Family	Social History
House environment	Social History
Work colleagues	Social History
Work Environment	Social History
Education	Social History
Alcohol	Social History

Table 12 lists all the PPHR terms which are reworded from ICPC2e elements to make them easier for lay people to understand or appear shorter for easier reading on cellphone screen.

**Table 12: Reworded PPHR Terms**

<b>Reworded PPHR Terms</b>	<b>Original ICPC2e Terms</b>
Acute upper respiratory infection	Upper respiratory infection acute
Allergic conjunctivitis	Conjunctivitis allergic
Angina	Ischemic heart disease with angina
Anxiety disorder	Anxiety disorder/anxiety state
Blood in stool	Melena
Blood in urine	Hematuria
Blood infection	Infection of circulatory system
Body sign	Vital signs

Bone	Musculoskeletal
Cancer	Malignant neoplasm
Contact allergy	Dermatitis contact/allergic
Disability	Limited function/disability
Dislocation	Dislocation/subluxation
Earache	Ear pain/earache
Eczema	Dermatitis/atopic eczema
Enlarged spleen	Splenomegaly
Fainting	Fainting/syncope
Feeling irritable-angry	Feeling/behaving irritable/angry
Gastroenteritis infection	Gastroenteritis presumed infection
General rash	Rash generalized
General swelling	Lumps/swellings generalized
Hearing problem	Hearing complaint
Hepatitis B/C	Hepatitis B
HIV-AIDS	HIV-infection/AIDS
Home life-Family	Home Problem
Hormones	Endocrine/Metabolic and Nutritional
Hyperthyroidism	Hyperthyroidism/thyrotoxicosis
Hypothyroidism	Hypothyroidism/myxoedema
Infectious conjunctivitis	Conjunctivitis infectious
Laryngitis-tracheitis	Laryngitis/tracheitis acute
Local rash	Rash localized

Local swelling	Lump/swelling localized
Mole	Nevus/mole
Mouth-Throat	Mouth
Muscle	Musculoskeletal
Muscle injury	Injury musculoskeletal NOS
Muscle-bone cancer	Malignant neoplasm musculoskeletal
Muscle-bone infection	Infections musculoskeletal
Nerves	Neurological
Pain with breathing	Pain respiratory system
Painful urination	Dysuria/painful urination
Palpitations	Palpitations/awareness
Plugged	Plugged feeling
Polio	Poliomyelitis
Post-traumatic stress	Post-traumatic stress disorder
Prostate hypertrophy	Benign prostatic hypertrophy
Pulse Rate	Pulse
Relation-disease	Relation
Rheumatic fever	Rheumatic fever/heart disease
Shingles	Herpes zoster
Sometimes high blood pressure	Elevated blood pressure
Stroke	Stroke/cerebrovascular accident
Sunburn	Solar keratosis/sunburn
Tinnitus	Tinnitus, ringing/buzzing ear
Tonsillitis	Tonsillitis acute

Too frequent urgent urination	Urinary frequency/urgency
varicose veins	Prominent veins
Vomiting blood	Hematemesis/vomiting blood
Warts/lumps	Molluscum contagiosum

### 4.3 Conclusion

This dissertation introduces personal health records and the importance of maintaining them throughout individuals lives. In order to maintain one s own health record all the time, it is important that the personal health record is always available and accessible. The proposed solution by this research is a portable personal health record for which the accessibility, availability and portability are achieved by maintaining health record in a cellphone.

The implemented prototype PPHR is a fully working application which can be installed in any cellphone which supports J2ME platform. Cellphones of this type are affordable by most people, and also support all PPHR s system requirements such as GSM connection and storage. The medical contents of PPHR are aligned to an international coding system ICPC2e, and ICPC2e includes a wide variety of health cases and types to ensure sufficiency of healthcare items in a health record. Functions and features of PPHR are also compared with ISO 18308, which is an international standard for requirements of electronic health record architecture. This is to maintain the quality of PPHR so that it meets the minimal requirements of a standard electronic health record.

The implemented PPHR is then compared with various similar applications which work in cellphone. PPHR has different features than other applications, such as GSM transmission channel which especially suits users in less urban areas. The usability of PPHR has also been tested in the evaluation, the usability result is acceptable and the numbers of participants who want to try using PPHR have increased at the end of evaluation.

To conclude, Malaysia s population exceeds 27.5 million, and the majority of residents are not aware of the existence and importance of personal health records. Imagine medical teams in Malaysia who do not have all the information about patients health,



the medical teams are at risk of functioning with incomplete information in caring for patients. Patients themselves are the only ones who can help to bridge the gap both today and even in the future. PPHR is one solution which can help the patients to bridge this gap, and the emergence of PPHR can arouse residents awareness of the personal health record importance in maintaining own health data.

#### 4.4 Future Work

Although the PPHR meets the criteria mentioned in this dissertation, there are still several processes which could improve it. The following is a list of features which can be implemented in the future:

- Compatible with even more cellphones
  - Currently the PPHR is only compatible with cellphones which support J2ME applications. Some popular cellphones like Windows Mobile, Android phones and Apple iPhones cannot run the PPHR yet. These phone types are becoming more common and popular. The PPHR should be compatible with as many cellphones as possible in order to make sure the PPHR can be widely used.
- Adopt suggestions by testers
  - There are many suggestions to improve the PPHR usability from the evaluation participants, such as touch screen, zooming, simplifying the listings in the PPHR, selections, data entering, etc. In the next phase, these suggestions can be adopted to improve the PPHR, depending on the limitations of J2ME and the cellphones. However, as mentioned above, if the PPHR can be compatible with more advanced cellphones, the specifications of the cellphones might support what the developers need in order to make the testers suggestions possible.
- Extend evaluation to more rural areas
  - Of the current participants who participated in the evaluation, only two had ever lived in rural areas. To get a better result about whether the PPHR is also suitable for people living in rural areas, more participants who live in rural areas should be involved, and the total number of participants should be increased. Although GSM has the widest coverage, testing whether most

residents living in rural area can successfully transmit data is very important to make sure data transmission of the PPHR works properly.

- Detail testing among more user groups
  - Since the main user group of PPHR is patients, most of PPHR evaluation participants are not medically trained people, only one is a pharmacist. Patients act as writers in PPHR, but as yet not much testing has been done yet from the readers such as clinicians. The PPHR shall not only be useful for patients, but it is also very important to make sure clinicians who have a role as reader are able to comprehend the health content produced from the PPHR. On the other hand, it also signifies the clarity of the content whether the data is sufficient to be used in medical diagnosis.
- Security and privacy
  - Current the PPHR does not implement any security features. The users are assumed to keep the PPHR data secure by their own cellphone security features such as locking the cellphone with a pass code. This type of security means that as long as a person has access to the phone, then that person will have access to the health data. Although stricter security seems right, it contradicts a case scenario mentioned in the dissertation a medical officer who needs to take care of an unconscious patient would not be able to read the patient's health history if he or she does not has the phone security code, which makes the health data inaccessible. Security and privacy are two very important criteria especially for health data, but approaches need to be inspected in order to maximize the security and privacy of the PPHR data and yet still be able to maintain the accessibility of the PPHR.
- Commercialization
  - After the PPHR is completely developed with satisfied features as mentioned above, it should be commercialized. However, this might not work in the normal sense of the word. The target audience of the PPHR are people who have simple cellphones and may live in rural areas with little or no Internet access; such people are often also poor. The PPHR is open source. One potential business model would see telecommunications

providers hosting online Web-based PHR systems and distributing the PPHR freely; the providers would earn from the SMSs sent from the PPHR for online backup. Of course there must be many other potential business models, but one must remain aware that the main purpose of Personal Health Records is to improve health and healthcare, rather than to generate wealth.

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## Appendices

### 6.1 A:PPHR Evaluation Form

Portable Personal Health Record (PPHR) a Java (J2ME) app for cellphones

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Evaluation Form

Dear tester,

Thank you for helping us evaluate the PPHR cell phone application. It is intended to allow any cell phone owner or user to keep track of his or her own health status, and to download that to a Personal Health Record system such as Google Health (which is closing in 2012), Microsoft Health Vault, MobileHealth2U (in Malaysia), or other.

First we need a few details about you, in order to see how different groups of people judge the PPHR.

Age	1-16 17-25 26-55 56-100
Gender	Male Female
Highest education	primary secondary university
Native language	English Deutsch 中文 Bahasa-Malaysia Other
Phone brand & model	

You should also have access to the PPHR User Guide Web page, which explains the usage in more detail.

The PPHR can be used in either Text mode , which should work on almost all cell phones which support Java, or Graphics mode , which might not work on phones with very small memory capacity.

We ask that you install the PPHR on your phone, try all the features, and should use the PPHR for at least 4-5 days then complete the form below. The form uses only the English terms, although the PPHR can be also used with Deutsch, 中文, and Bahasa Malaysia. See the User Guide.

Command	Choices	Number of times you used	Overall satisfaction (1 = terrible, 3 = OK,	Remarks, suggestions

		this	5 = great)	
GO			1 2 3 4 5	
Make new entry				
	Alert		1 2 3 4 5	
	Problem (Text mode)		1 2 3 4 5	
	Problem (Graphics mode)		1 2 3 4 5	
	Body signs		1 2 3 4 5	
	Results		1 2 3 4 5	
	Medication		1 2 3 4 5	
	Procedure (Text mode)		1 2 3 4 5	
	Procedure (Graphics mode)		1 2 3 4 5	
	Diagnosis		1 2 3 4 5	
	Notes		1 2 3 4 5	
	Vaccination		1 2 3 4 5	
	Person		1 2 3 4 5	
	Social-history		1 2 3 4 5	
	Family-history		1 2 3 4 5	

	Medical devices		1 2 3 4 5	
View Alert			1 2 3 4 5	
View All			1 2 3 4 5	
View selected (Text mode)				
	1A) select one Problem		1 2 3 4 5	
	1B) do not select a specific Problem - All Problems		1 2 3 4 5	
	2A) select a range of dates to view		1 2 3 4 5	
	2B) do not select any particular date range All Dates		1 2 3 4 5	
	3A) search for a keyword in the record		1 2 3 4 5	
	3B) do not search for any specific keyword (leave that field blank)		1 2 3 4 5	
View selected (Graphics				

mode)				
	Keyword entry		1 2 3 4 5	
	Expand		1 2 3 4 5	
	View selected		1 2 3 4 5	
Mark Error			1 2 3 4 5	
PPHR -> SMS	[The default number is our Malaysian SMS gateway. You may enter any cellphone number you wish]		1 2 3 4 5	
Help			1 2 3 4 5	
Back			1 2 3 4 5	
Exit			1 2 3 4 5	
Overall			1 2 3 4 5	

Do you keep all your health records?	No	Some	Yes
The instructions are clear and easy to understand.	No	Moderate	Yes
The PPHR entry list have sufficient element items for you to insert medical data.	No	Some	Very Sufficient
You can get information you want from PPHR.	No	Some	Yes
You can enter a record entry in a short time.	Slow	Moderate	Fast
You can navigate entries in a short time.	Slow	Moderate	Fast
You will consider using PPHR to maintain your health record in the future.	No	Maybe	Yes