

國立臺灣大學電機資訊學院生醫電子與資訊學研究所

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個人健康紀錄平台運用於糖尿病照護

Platform of Personal Health Records for Diabetes Mellitus Care



指導教授：賴飛羆 博士

Advisor: Feipei Lai, Ph.D.

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## 中文摘要

慢性疾病的照護需要病人自我健康管理的配合，藉由改善病人的生活習慣以達到緩和或改進病人的疾病與健康情況。傳統的自我健康管理，病人利用紙本或是文書軟體紀錄自己的生活習慣、生理數值、或是用藥以及就醫紀錄等。此種方式在資料管理及維護上有諸多不便之處。本篇研究希望藉由實行個人健康管理平台，幫助病人紀錄生理數值和生活習慣與個管師良好互動，最後達到促進病人主動積極的參與健康照護並改善其健康狀況。

關鍵字：個人健康紀錄平台，糖尿病照護，連續性照護文檔。



## **ABSTRACT**

The health care of chronic disease need combine with patient self-management for improving patient's lifestyle and health behavior and finally improving patient's disease and health status. In traditional self-management, patients record their health behavior, vital signs, medication and healthcare encounters on paper or by word processing software. These recording manners may result in difficult to maintain or manage data. This study was to build a personal health record application to help patients record their vital signs, health behavior and message or interact with case managers, and finally assist patients in actively involving their health care and improving their health status.

KeyWord: personal health record, diabetes health care, continuity of care document



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口試委員會審定書 .....#

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# Chapter 1 Introduction

## 1.1 Foreword

Diabetes is a chronic disease that occurs when the pancreas does not produce enough insulin, or when the body cannot effectively use the insulin it produces. Hyperglycemia, or raised blood sugar, is a common effect of uncontrolled diabetes and can cause serious cardiovascular disease and nerves disease such as stroke and diabetic neuropathy if not properly treated [1].

Patients with poor management can result in increased morbidity, mortality, and overall costs. Self-monitoring of blood sugar with relevant lifestyle information may be useful to service provider for improving patient self-management.

Because self-management of patient's health status and behavior by paper record or word processing programs may not be easy to manage the data and not convenient to access when they want to use them. So there must have some tools to help diabetic patients to manage their health related data and it is also accessible anywhere and anytime when patients want to use.

The Personal Health Record (PHR) is a set of tools that allow users to record and access medical record information. The PHR system offers an integrated and comprehensive view of health information, including the information that people

generate themselves, such as medications, family history, vital signs and test results.

With a PHR, users can record and track the progress toward their health goal and share their health information such as blood pressure, daily diets and exercises with care providers. The provider can use the information to adjust patient's therapy and health goal and give some advices to assist patient in changing and maintaining health behaviors.

## **1.2 Motivation and Objective**

As mentioned above the diabetic patients with poor care may result in increased morbidity, mortality, and overall costs. And the personal health record seems to be a good manner to help patients to control and manage their health related data and finally to engage patients in their health care.

In this approach we want to build a web based PHR application for diabetic patients and case managers who responsible for monitoring patients' health status and providing advices for helping patients maintain their behavior.

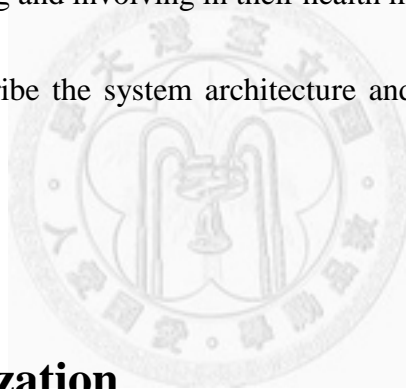
Our application has two separated interface, one for diabetic patients to record their medical or health related data as well as provide some knowledge to teach patient how to deal with some situations and the other one for case mangers to monitor patients' vital signs, insulin delivery data and daily diets, both users can message each other

through the inner message utility.

The application can allow patients to upload their glucometer readings either from web network and 3G mobile telecommunications from our partner's commercial device or just open the patient side portal and enter their readings into the form then send to our server.

We hypothesized that with our application patients will keep on recording their vital signs and health related data, consulting and communication with case managers, finally being more activating and involving in their health management.

In this study we describe the system architecture and the implementation of our application.



### **1.3 Thesis Organization**

The rest of this thesis is organized as follows. Chapter 2 introduces the background and related works. The method and system architecture are described in chapter 3. The results and discussions are in chapter 4 and chapter 5 respectively. The conclusion and the future work are in the last chapter.

## Chapter 2 Background and Related Work

### 2.1 Personal Health Record

Diabetes is a common chronic disease that needs long term treatment and control. Unlike acute diseases, chronic diseases require patients to take a long time and put more effort into lifestyle management such as diet, exercise and compliance with medications. Self-management takes an important role in the treatment process, as previous study has shown that with education and training improving self-management skills result in improved disease-related outcomes like decreased HbA1c (glycated hemoglobin), weight loss and increased physical activity [2].

The research by Pablo et al. [3] found that as many as 40% of men and 30% of women were unaware their disease condition in Colombia and Cherlotte et al. [4] also showed that nearly 70% in Denmark, 61% in the Netherlands and 47% citizens in Australia were unaware of their disease.

Thanks to the information technology (IT) there are many applications developed for helping patient management, patient education and training, improving communication with medical staff and compliance with medical prescription. The following summarized a few of examples of IT applications in patient self-management.

The "Patient Gateway" is a patient web portal not only allows patients to access to

provider's EMR system (e.g. reading their medical record (laboratory results and guidelines), correcting or modifying medication list or allergy list and making journal for office visit preparation) but also provide some decision support and examination reminder [5]. The "Diabetes Connected Health" is a remote blood glucose monitoring application which allows patient to upload glucometer readings from commercially available glucometers, make notes or comments on each reading and message with their care providers [6]. Besides the above two applications many studies showed their applications improving clinical outcomes with improved patients-physicians communication [7, 8].

The Personal Health Record (PHR) is a set of tools that allow user to record and access personal health record information. The ideal of Personal Health Record is not new. Individuals collecting, organizing, and keeping in file folders, in paper-based is the traditional way of building medical records, but it is not easy to maintain and manage. The information communication technology (ICTs) and internet spreading has made personal health record feasible using personal computers, personal digital assistants or smart phones.

Compared with EMR (Electronic Medical Record) system, there are several characteristic of PHR. First, the main actor is the individual or the consumer is no longer a patient. Second, the PHR is intended for individual use and the data in the PHR

is totally patient controlled, whereas the EMR is for healthcare staffs and the data in the EMR is maintained by the healthcare provider. Third, the PHR cannot be considered as a static data repository, it is also composed of knowledge and tools for helping people in taking an active role in their own healthcare.

The Markle Foundation's Connecting for Health collaborative, a public-private endeavor working toward an interoperable health information infrastructures defined PHR in their report on the subject as:

**“An electronic application through which individuals can access, manage and share their health information, and that of others for whom they are authorized, in a private, secure, and confidential environment.” [9]**

The Markle Foundation description is one of many PHR descriptions, as many definitions are evolving; the dominant future PHR description remains unknown.

## 2.2 Continuity of Care Document (CCD)

The Continuity of Care Document (CCD) is a collaborative effort of Health Level 7 (HL7) and American Society for Testing and Materials (ASTM) to foster interoperability of clinical data to allow physicians to send electronic medical information to other providers without loss of meaning. The CCD is the integration of two complementary specifications [ASTM Continuity of Care Record (CCR), and HL7 Clinical Document Architecture (CDA)] developed by separate standards development organizations, representing a complete implementation of CCR with combining the best of HL7 technologies with the richness of CCR's clinical data representation.

The CCR is a patient health summary standard contains the most relevant and timely core health information about a patient such as demographics, insurance information, diagnoses and problem list, medications, allergies and care plan. CCR represents a "snapshot" of a patient's health data that can help caregiver to review patient' health status.

As a CDA implementation, CCD contains a header and a body. The header identifies and classifies the document and provides information on authentication, the encounter, the patient and the involved providers; the body contains the clinical report and can be structured or not.

Figure 1 shows part of the CCD header, we can see that the CCD is a CDA

document following patterns of constraints, or templates, like the CCD template (1), these patterns supporting interoperability between CCD and other documents which constraints on CDA and templates defined by CCD. The following we describe some features of CCD in Figure 1, the EffectiveTime is the time document been created (2), the RecordTarget identifies the patient and organization and other people and personal data associated with the patient (3), and the Author identifies person or device who created the summary.

```

<typeId root="2.16.840.1.113883.1.3" extension="POCD_HD000040"/>
<templateId root="2.16.840.1.113883.10.20.1"/> (1)
<!-- CCD v1.0 Templates Root -->
<id root="db734647-fc99-424c-a864-7e3cda82e703"/>
<code code="34133-9" codeSystem="2.16.840.1.113883.6.1" displayName="Summarization of episode note"/>
<title>Good Health Clinic Continuity of Care Document</title>
<effectiveTime value="20000407130000+0500"/> (2)
<confidentialityCode code="N" codeSystem="2.16.840.1.113883.5.25"/>
<languageCode code="en-US"/>
<recordTarget>
  <patientRole>
    <id extension="996-756-495" root="2.16.840.1.113883.19.5"/>
    <patient>
      <name>
        <given>Henry</given>
        <family>Levin</family>
        <suffix>the 7th</suffix>
      </name>
      <administrativeGenderCode code="M" codeSystem="2.16.840.1.113883.5.1"/>
      <birthTime value="19320924"/>
    </patient>
    <providerOrganization>
      <id root="2.16.840.1.113883.19.5"/>
      <name>Good Health Clinic</name>
    </providerOrganization>
  </patientRole>
</recordTarget>
<author>
  <time value="20000407130000+0500"/>
  <assignedAuthor>
    <id root="20cf14fb-b65c-4c8c-a54d-b0cca834c18c"/>
    <assignedPerson>
      <name>
        <prefix>Dr.</prefix>
        <given>Robert</given>
        <family>Dolin</family>
      </name>
    </assignedPerson>
    <representedOrganization>
      <id root="2.16.840.1.113883.19.5"/>
      <name>Good Health Clinic</name>
    </representedOrganization>
  </assignedAuthor>
</author>

```

Figure 1 Part of CCD Header



The CCD body consists of one or more sections that can nest and that are related through a component relationship. Figure 2 displays part of CCD Body's Family History section, the subject is the RecordTarget's father (1) who suffered from Myocardial Infarction (2) at the age of 57 (4) and the disease caused him death (3).

```

<entry typeCode="DRIV">
  <organizer moodCode="EVN" classCode="CLUSTER">
    <templateId root="2.16.840.1.113883.10.20.1.23"/>
    <!-- Family history organizer template -->
    <statusCode code="completed"/>
    <subject>
      <relatedSubject classCode="PRS">
        <code code="9947008" codeSystem="2.16.840.1.113883.6.96" displayName="Biological father"/>
        <subject>
          <administrativeGenderCode code="M" codeSystem="2.16.840.1.113883.5.1" displayName="Male"/>
          <birthTime value="1912"/>
        </subject>
      </relatedSubject>
    </subject>
  </component>
  <observation classCode="OBS" moodCode="EVN">
    <templateId root="2.16.840.1.113883.10.20.1.42"/>
    <!-- Family history cause of death observation template -->
    <id root="d42ebf70-5c89-11db-b0de-0800200c9a66"/>
    <code code="ASSERTION" codeSystem="2.16.840.1.113883.5.4"/>
    <statusCode code="completed"/>
    <value xsi:type="CD" code="22298006" codeSystem="2.16.840.1.113883.6.96" displayName="MI"/>
    <entryRelationship typeCode="CAUS">
      <observation classCode="OBS" moodCode="EVN">
        <id root="6898fae0-5c8a-11db-b0de-0800200c9a66"/>
        <code code="ASSERTION" codeSystem="2.16.840.1.113883.5.4"/>
        <statusCode code="completed"/>
        <value xsi:type="CD" code="419099009" codeSystem="2.16.840.1.113883.6.96" displayName="Dead"/>
      </observation>
    </entryRelationship>
    <entryRelationship typeCode="SUBJ" inversionInd="true">
      <observation classCode="OBS" moodCode="EVN">
        <templateId root="2.16.840.1.113883.10.20.1.38"/>
        <!-- Age observation template -->
        <code code="397659008" codeSystem="2.16.840.1.113883.6.96" displayName="Age"/>
        <statusCode code="completed"/>
        <value xsi:type="INT" value="57"/>
      </observation>
    </entryRelationship>
  </observation>
</component>

```

Figure 2 Part of CCD Body

## Chapter 3 Method

### 3.1 Requirement

In order to define the clarity functions of today's PHR, we review some paper [10–29] that motioned or discussed about PHR. Based upon the review, we defined six domains: user controlled, lifelong repository, internet based, interoperability, sharing, and tools for assisting consumer (Table1).

Table 1 The identified requirements

Domains	Number
User controlled	16/20
Lifelong repository	13/20
Internet based	11/20
Interoperability	14/20
Sharing	17/20
Tools for assisting consumer	16/20

1. User controlled means the PHR maintained, managed and shared by the users. The data in PHR are owned by the users not the system providers, without the consent

of the users the data cannot be used in investigations, researches or any other profit, non-profit use.

2. Lifelong repository means the PHR should contain user's lifetime medical or health data for the continuity of care. Based upon these data, caregiver can make more correct treatment decision while lowering the risk in the treatment process and compare family member's disease risk at the genetic and environmental levels [30].
3. Internet based means the application could be accessed from any place where internet is available. By the internet, users can access and manage their data from a computer, PDA or Smartphone making the application portable and convenient to user and the application can link to other available sources for useful information.
4. Interoperability means the application could connect with other systems for data transmission. For instance, PHR applications interoperating with health organizations allow retrieving information about physician's advices, therapy adjustment and test results, refilling prescription and scheduling appointments.
5. Sharing means users can share their health information with whomever they choose. Usually users share their information with relatives or caregiver, that could let them realize their health status and feedback useful information or advices for helping users in managing their health.
6. Tools for assisting consumers means the PHR application must provide some tools

for assisting users in involving their health care. The tools may have the feature of graphic representation of vital signs, the vital signs range setting and inner messaging with caregivers, etc.

## **3.2 Architecture**

According to the requirements mentioned on earlier section, our application needs to be accessible from any place where internet is available so it must be web based. The web based has other benefits like crossing platforms, linking to external site for useful information and retrieving or sending data by web services.

Because the security and privacy concern, we use HTTPS for providing encrypted communication and secure identification. The account of a user or consumer is created by case managers with a set of password and then given it to the user for user login. When a user forgot the password, the only way is asking the case managers for resetting the password.

Our application was implemented as two layers architecture. The first layer was the web server for data retrieving and logic processing, and some JavaScript functions on user client side for data validation, low-level interaction and animation. The second layer was the DB server for data reserving and retrieving. We also use web services to get useful information and deal with some situations such as retrieving Google weather

information and sending SMS messages to case managers.

Our application uses JavaScript in client side for low level interaction and Ajax for smooth operation. The Asp.net webform and Microsoft SQL server 2008 are used in the server side for data and logic processing, the web service for retrieving data or providing services. The client side JavaScript helps data validation prevent data missing or error input and low level interaction and animation such as the JQuery datepicker not only provides nice looking UI for user interaction but also returns right date format that can prevent data format error in the server side data inserting action. The JQuery is a popular JavaScript framework like other JavaScript framework (Google Web Toolkit, Prototype and YUI) which offers easy to use and friendly API helps developers write JavaScript functions without bothering about dealing with crossing browser.

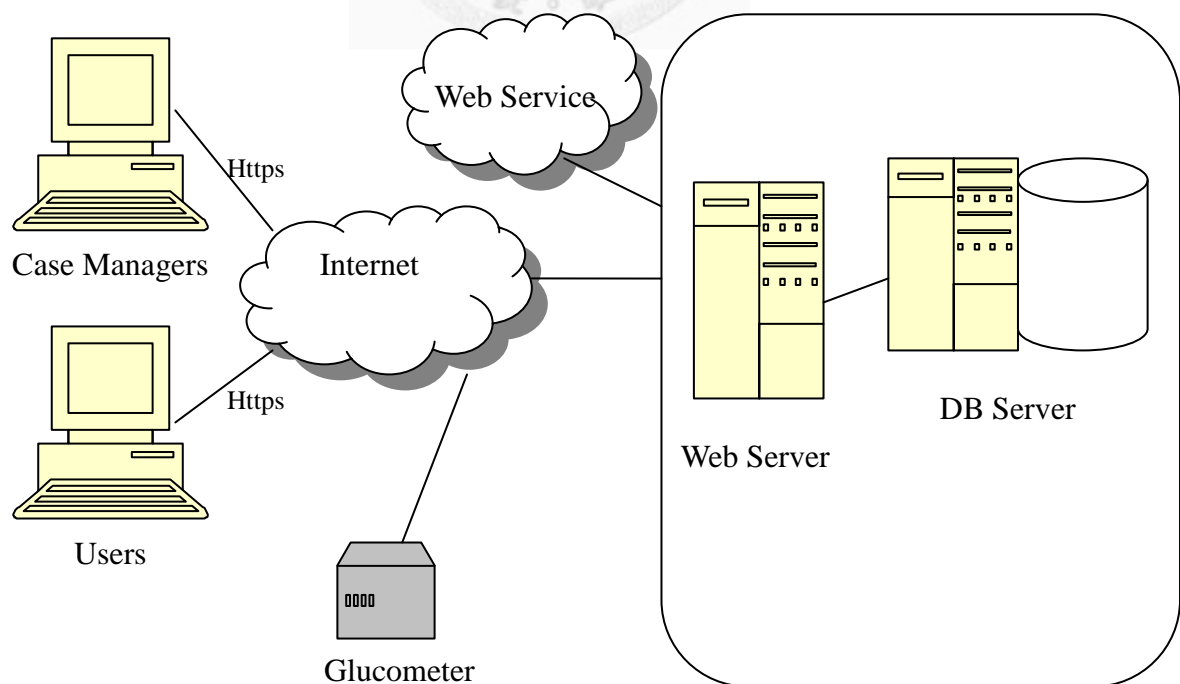


Figure 3 System Architecture

The JQuery UI provides dynamic interaction with client user which allows data presentation or inputting in a more friendly manner. The JQuery datatable which transforms static table into a dynamic table with pagination and automatic sorting when we click on table headers, just need a simple declaration. Some UIs also offer properties that can connect to server side for data retrieving and processing by Asynchronous JavaScript XML (Ajax) making itself more powerful and smooth in data presentation.

The Ajax (Asynchronous JavaScript XML) [31] is a manner that client side JavaScript function sending request to server side for data retrieving or processing; after server side receiving the request, the server side writes the results on a page as text, xml structure or JSON (JavaScript Object Notation) [32] structure and send back to client underlying; the client side JavaScript deals with the text on the page and presents data on the existing page user faced without interfering user behavior.

With JQuery API, we do not need to deal with the XMLHttpRequest object supported by different browsers, just using Ajax API and entering the parameters like the data we want to send to the server, the server side URL and the handler which is responsible for dealing with server response. Because of the convenient and cross browser property, we use JQuery to retrieve the Html DOM element and bind even handler for data validation, pre-processing and finally send data back to the server by

Ajax.

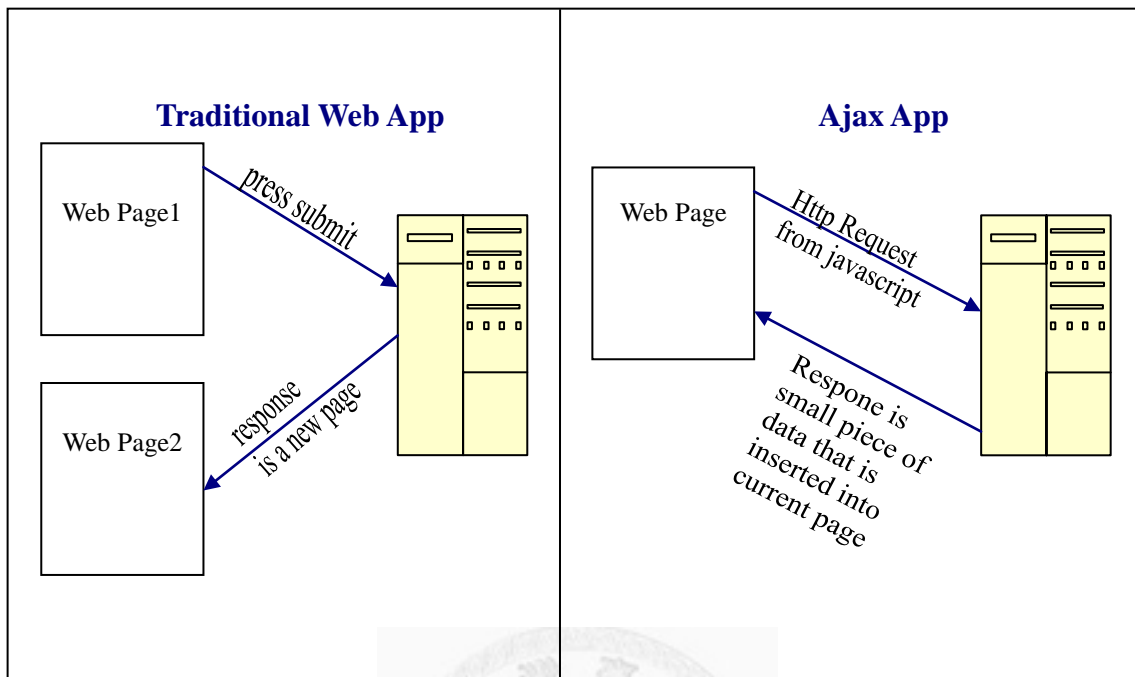


Figure 4 Asynchronous JavaScript XML (Ajax)

On the server side we use C# Language, ASP.net web Forms and .Net framework 3.5 to develop our application. The Web Forms is a Rapid Application Development (RAD) technology which lets developers quick build web application without concerning the complexity in web controls. The other advantage is that the web Form is a mature product of Microsoft supported by a lot of .net framework server controls and third-party controls. Although the trend of web development is the Model-View-Controller (MVC) design pattern that allows developers to separate business logic from the user interface and application input but it needs developers to take much effort on the system design and separation. The web Form allows quick development and deploy to save time and money on businesses.

The database we used was Microsoft SQL server 2008 relational database which can be integrated into the developing environment. The adoption allows convenient management of data and also supported by the Microsoft entity framework, a object-relational mapping (ORM) framework, transforming the database schema to a conceptual application model, allows developers to manipulate database as an object, which simplifies data manipulation work.

Our approach uses web services to get extra useful information such as the Google weather information and pollution standards index (PSI) and to send SMS message to case managers when user's input vital signs value is abnormal. The advantage of the web service is reusability and interoperability. Web service is based on XML and HTTP, the XML provides a language that can be used between platforms and still expresses messages and functions, the SOAP (Simple Object Access Protocol) is used to transfer the XML. By using web service, our application can connect with other systems, and by using the API which provided, we can use their resources either the data or the functions to enrich our application without taking our effort on developing the same service again.

### **3.3 Document**

The interoperation and sharing are needed based upon the requirements we identified in section 3.1. The CCD is an XML-based markup standard intended to



specify the encoding, structure and semantics of a patient summary clinical document for exchange. The CCD presents as a "snapshot" of a patient's health data that can help caregivers to review patient' health status. Because the CCD architecture is inherent from CDA which is based on the HL7 Reference Information Model (RIM) and the HL7 Version 3 Data Types. Compared to the CCR, the CCD not only contains the sections of patient health summary as the CCR does but also is compatible with other clinical documents like discharge summary. In addition, the CCD shares the HL7 Reference Information Model (RIM) which is sufficient to support the general international exchange requirements and is compatible with other standards like Clinical Data Interchange Standards Consortium (CDISC). So here we choose the CCD as the document standard for clinical document exchanging.

Building the components of the CDA by ourselves may be complex and difficult. So we survey the available tools or library on the internet, fortunately, we found the Model-Driven Health Tools (MDHT) Project [33] which used the UML to model the CDA architecture and generate the respective classes; The feature of their project is that user can modify their default model and generate respective classes but here we just use the default model and classes they provided.

Because the plug-in and library their provided are based on java and the Eclipse (an integrated development environment (IDE) for Java), so we just use the Eclipse and java

for the CCD document generation. The JSP (java server pages) is a java solution in creating dynamic web pages. The JSP model is composed of JavaBean, JSP and Servlet as the Model-View-Controller (MVC) design pattern [34], but here we just use Servlet as controller to retrieve data from database and then generate CCD file without the need of the JSP to preset views on pages or JavaBeans carried data as model and transmit between pages or between page and Servlets.

Because the CCD is just a semantic document structure of presentation clinical document, it still needs some terminology coding system like SNOMED CT and LOINC to make up the insufficient in the exchange procedure. Here we use the SNOMED CT and Rxnorm [35] coding system for terminology exchange. There are some available APIs or web services of the two coding systems on the internet but they only can retrieve the code of approximate terms, so we must use the standard terms in our PHR application if we want to exactly map terms and code. The benefit of using web services to retrieve code is that sometimes the old code will be replaced with a new code, the web service just returns the new code, not the no longer used old code. Because in the design face we had not considered carefully in this domain, our applications still have some terms that cannot exactly map with the SNOMED CT, so these terms must be mapped by ourselves. The Rxnorm code has the same situation as mentioned above that some drug names case managers provided us or the drug names

registered in the Department of Health in Taiwan cannot be mapped to the Rxnorm code, we must pick similar ones and assign code to them. Figure 5 shows the diagram of the CCD generation procedure.

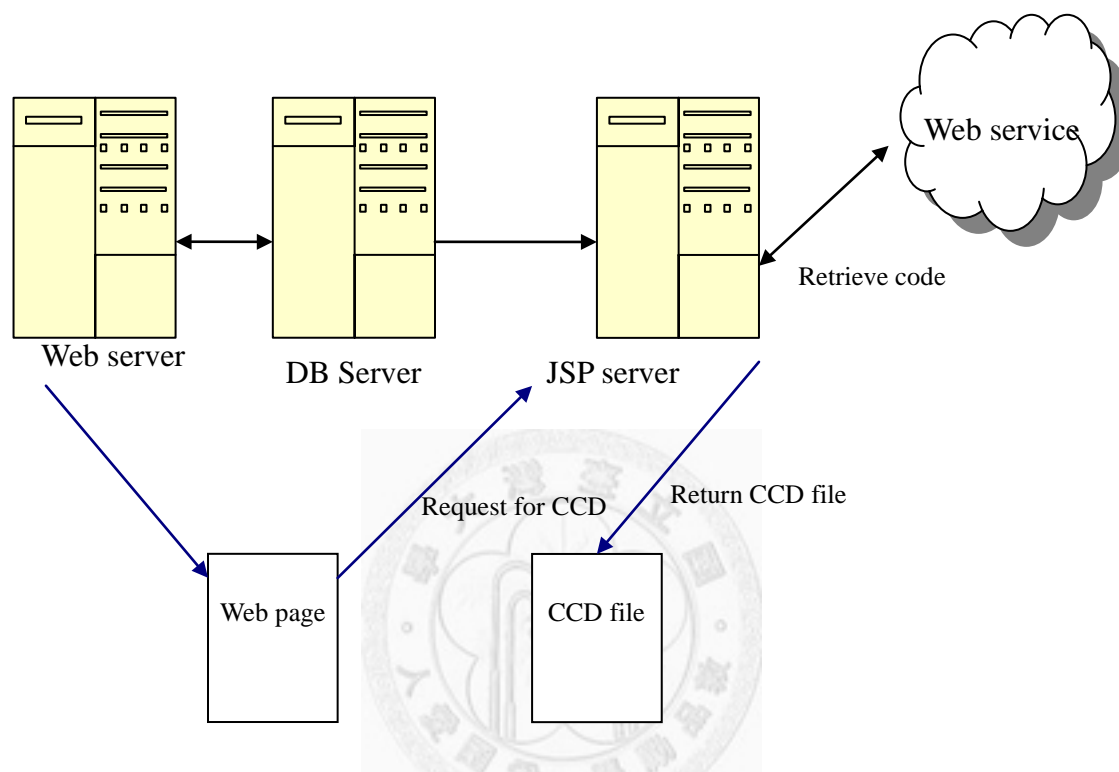


Figure 5 CCD generation

Our approach prefers to let a glucometer feed the readings directly to our server from available linking technology such as the phone-line, the internet or the 3G mobile telecommunications. The commercial available glucometers (TD3261G and TD-9014) from our partner “TaiDoc” can access and send a request message string to our server. In the case manager interface, case managers help user register glucometer therefore we can map the user with the glucometer’s serial number while the request message is accepted and extracted. The message must be parsed and then extracted the vital signs

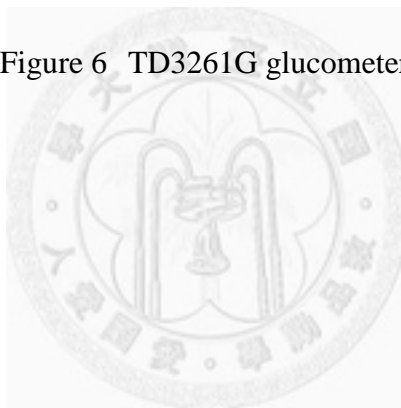
readings and the status like fasting blood glucose (AC), Postprandial glucose test (PC), finally the personal vital signs threshold is compared with that case managers set for every user. After comparing the personal vital signs range, if the reading is not in the normal range our application will call the SMS message web service for sending alert message to their assigned case manager.

The device TD3261G glucometer, with 3G mobile telecommunications embedded, audible design guides users through setup, testing and result reporting, which allow users to transfer their glucose readings to our server right away, no need to find and plugin the device to internet or telephone network. The voice design guides elder users to familize with the device and minimize the "digital-divide".

For some users familiar with other commercial glucometers and not willing to try the devices we provide, we offer other manner to help them record their readings. In the user interface of our application, we provide forms to let user key in readings, detected time and status of blood glucose or blood pressure. Here we use the Ajax to transfer data, user input data transferred to the server and saved to database by first Ajax request, after finished, the second Ajax requested for data to display plots on diagram. There allow users to see their vital signs diagram updating right after new readings being submitted.



Figure 6 TD3261G glucometer



## Chapter 4 Results

Our application has two separated user interfaces, one for case managers and the other for users or customers. The case manager interface has the functions and tools they need in the patient enrolling process, monitoring user vital signs uploading and messaging to user or answering user's questions. The user interface help users to record their health status like vital signs, diet and exercise, to message to case managers and offer some patient educations.

### 4.1 Case manager interface

In the case manager interface the first panel is the account management which allows case managers to create user account for user and set personal vital signs threshold, reset password while users forget and register glucometers with users (Figure 7).

The image shows two screenshots of a web application interface. The top screenshot is titled '儀器登記' (Instrument Registration) and features a form with the following fields: '身份證字號' (ID Number) with a radio button selected, '居留證' (Residence Permit) with a radio button, '血糖/血壓機序號' (Blood Sugar/Blood Pressure Machine Serial Number), 'Gateway序號' (Gateway Serial Number), and '試紙密碼' (Test Paper Password). There are '確定' (Confirm) and '重設' (Reset) buttons at the bottom. The bottom screenshot is titled '新密碼' (New Password) and features a form with '使用者帳號' (User Account) and '密碼' (Password) fields, with '確定' (Confirm) and '重設' (Reset) buttons at the bottom. Both screenshots have a navigation bar at the top with tabs for '病人帳號' (Patient Account), '個管師帳號' (Case Manager Account), '儀器登記' (Instrument Registration), and '新密碼' (New Password).

病人帳號				個管師帳號		儀器登記		新密碼	
建立帳號				修改帳號					
建立病人帳號									
病患群組：	===請選擇===			病歷號碼：					
使用者帳號：				使用者姓名：					
<input checked="" type="radio"/> 身份證字號：				生日：					
<input type="radio"/> 居留證：									
性別：	請選擇			血型：	請選擇				
所屬個管師：	test								
身高：				體重：					
密碼：				確認密碼：					
家用電話：				手機：					
格式：02-12345678				格式：0911-1111111					
電子郵件：				Skype：					
地址：									
個人生理數值標準									
上傳次數：	次數：			單位：	請選擇				
縮收壓：	高：	140	低：	90					
舒張壓：	高：	90	低：	50					
血糖：	高：	275	低：	70					
心跳：	高：	100	低：	60					
呼吸：	高：	20	低：	16					
建立使用者									

Figure 7 Account management panel

The second panel let case managers view user's personal data and link to the user's interface to view the records (diet, exercise and insulin inject) users updated. Other tabs let case managers view the value of vital signs either uploaded from provided devices or users entered and make some manipulations such as phone recording and inner messaging (Figure 8).

異常數值   上傳清單   病人清單

Show 10 entries   Search:

姓名	手機	室話	群組	上傳資料	個管師	電訪	寄信
黃	無	02	DM	0 筆	鄭	新增電訪	寄信
黃	09	02	DM	45 筆	鄭	新增電訪	寄信
黃	09	02	DM	242 筆	陳	新增電訪	寄信
高	09	09	DM	12 筆	鄭	新增電訪	寄信
顏	09	02	DM	199 筆	陳	新增電訪	寄信
陳	09	02	DM	29 筆	陳	新增電訪	寄信
陳	09	02	DM	106 筆	陳	新增電訪	寄信
陳	04	02	DM	289 筆	鄭	新增電訪	寄信
關	09	02	DM	0 筆	鄭	新增電訪	寄信
鄭	09	02	DM	4 筆	鄭	新增電訪	寄信

Showing 1 to 10 of 61 entries

異常數值   上傳清單   病人清單

查詢範圍: 所有人   一週

Show 10 entries   Search:

量測時間	上傳者	類別	數值	儀器上傳	有無異常
2011/12/	林	血糖	169	否	無
2011/12/	林	體重	64.5	否	無
2011/12/	柯	血糖	161	是	無
2011/12/	王	體重	79.9	否	無
2011/12/	王	心跳	85	否	無
2011/12/	王	血壓	125/75	否	正常 / 正常
2011/12/	劉	心跳	68	是	無
2011/12/	劉	血壓	112/73	是	正常 / 正常
2011/12/	洪	心跳	89	是	無
2011/12/	洪	血壓	132/75	是	正常 / 正常

Showing 1 to 10 of 759 entries

異常數值   上傳清單   病人清單

查詢範圍: 所有人   一週

Show 10 entries   Search:

量測時間	上傳者	類別	數值	情形
2011/12/	陳	血糖	287	過高
2011/12/	林	血壓	147/85	過高 / 正常
2011/12/	林	血糖	1	過低
2011/12/	姚	血壓	153/65	過高 / 正常
2011/12/	姚	血糖	297	過高
2011/12/	詹	血糖	67	過低
2011/12/	郭	血壓	143/84	過高 / 正常
2011/12/	詹	血糖	50	過低
2011/12/	洪	血糖	321	過高
2011/12/	柯	血糖	67	過低

Showing 1 to 10 of 110 entries

Figure 8 User data



The third panel displays the phone record list that helps case managers review or recheck the users' status that she/he is responsible (Figure 9). The fourth panel displays the inner messages that users sent to their assigned case managers, allows case managers to look user questions or user responses and finally make reply (Figure 10).

Show 10 entries Search:

紀錄時間	姓名	通話類別	標題	個管師	處理進度
2011/12/	江	OUT		陳	已完成 <a href="#">檢視</a>
2011/12/	江	OUT		陳	已完成 <a href="#">檢視</a>
2011/12/	王	OUT		陳	已完成 <a href="#">檢視</a>
2011/12/	黃	OUT		陳	已完成 <a href="#">檢視</a>
2011/12/	俞	OUT		陳	已完成 <a href="#">檢視</a>
2011/12/	李	OUT		陳	已完成 <a href="#">檢視</a>
2011/12/	柯	OUT		陳	已完成 <a href="#">檢視</a>
2011/12/	柯	OUT		陳	已完成 <a href="#">檢視</a>
2011/12/	詹	OUT		陳	已完成 <a href="#">檢視</a>
2011/12/	顏	OUT		陳	已完成 <a href="#">檢視</a>

Figure 9 Phone record

訊息紀錄 備份訊息

Show 10 entries Search:

狀態	讀取	寄件者	標題	寄件時間	閱讀
未回覆	未讀	李		2011/12/	閱讀
未回覆	已讀	陳		2011/12/	閱讀
未回覆	未讀	陳		2011/12/	閱讀
未回覆	已讀	洪		2011/12/	閱讀
已回覆	已讀	柯		2011/12/	閱讀
已回覆	已讀	鄭		2011/12/	閱讀
已回覆	已讀	陳		2011/12/	閱讀
已回覆	已讀	柯		2011/12/	閱讀
未回覆	已讀	柯		2011/12/	閱讀
未回覆	已讀	陳		2011/12/	閱讀

Figure 10 Messages

## 4.2 User side interface

In the user side interface, users can modify their demographic data such as address and phone number, record data as the Department of Health Diabetes notebook and access patient education materials. The most important is letting users record their vital signs data and health information and message with case managers for assisting users in self-management.

姓名：	<input type="text"/>	身分證字號：	<input type="text"/>
病歷號：	<input type="text"/>	性別：	F
血型：	B	生日：	1954/07/18
身高：	162	體重：	59
電話： 格式：02-12345678	<input type="text"/>	手機： 格式：0911-1111111	<input type="text"/>
電子郵件：	<input type="text"/>	Skype：	<input type="text"/>
地址：	<input type="text"/>		
<input type="button" value="確定"/>			

[寄信給個案師](#)

訊息紀錄
備份訊息

Show 10 entries
 Search:

狀態	讀取	寄件者	標題	寄件時間	閱讀
未回覆	未讀			2011/12/	閱讀
未回覆	已讀			2011/12/	閱讀
未回覆	未讀			2011/12/	閱讀
未回覆	已讀			2011/12/	閱讀
已回覆	已讀			2011/12/	閱讀
已回覆	已讀			2011/12/	閱讀
已回覆	已讀			2011/12/	閱讀
已回覆	已讀			2011/12/	閱讀
未回覆	已讀			2011/12/	閱讀
未回覆	已讀			2011/12/	閱讀

Figure 11 Demographic Data

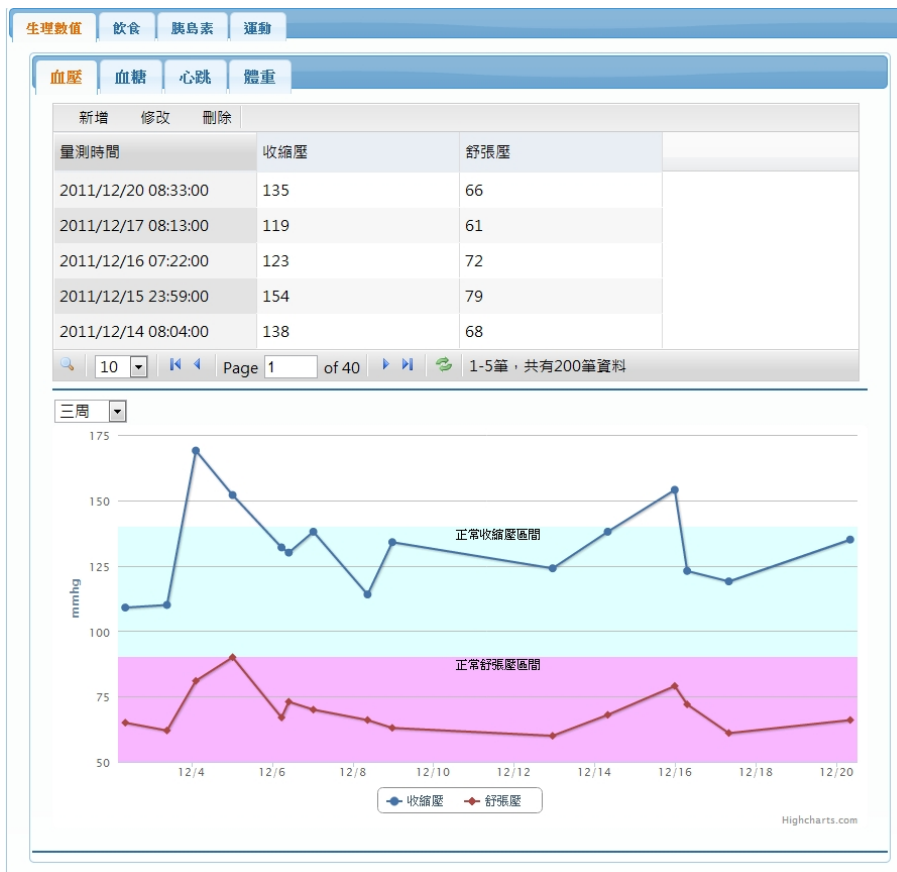


Figure 12 Vital signs records

認識低血糖 生病日之血糖處理 糖尿病足部照護

[ 低血糖是甚麼 ] [ 低血糖的症狀 ] [ 低血糖的原因 ] [ 低血糖的處理方式 ] [ 如何預防低血糖 ]

**低血糖是甚麼**

低血糖是因血糖降低(<70mg/dl), 無法供應身體細胞正常生理活動所需的足夠能量。  
嚴重的低血糖會造成腦部受創甚至死亡  
而造成低血糖症狀的數值因人而異, 有些人長期處在高血糖狀態下, 即使血糖下降到良好控制範圍內, 也可能會出現類似低血糖的徵兆。

**低血糖的症狀**

虛弱、發抖、饑餓、頭暈、皮膚蒼白、流汗、心跳加速、發冷汗、無法集中注意、嘴部周圍麻刺感等都是低血糖的症狀。  
嚴重的低血糖甚至會意識不清、抽筋、昏迷。

**低血糖的原因**

(一)藥物方面

1. 服藥過量或是服藥後沒進食
2. 胰島素量不正確
3. 注射時間不規律

(二)飲食方面

1. 進食時間不當
2. 忽略或延遲正餐/點心
3. 醃類份量不規律

Figure 13 Educational material

## 4.3 CCD document

The CCD document can provide a snapshot of a user's health status for provider or any one with whom the users want to share. The document, as a clinical document standard, can be used for information interoperation between different systems.

<b>Patient:</b>	██████████	<b>MRN:</b> 123456
<b>Birthdate:</b>	August 7, 1983	<b>Sex:</b> Female
<b>Service Event:</b>	August 7, 1983 - December 24, 2011	

**Table of Contents**

- [Family history](#)
- [Medications](#)
- [Vital Signs](#)

**Family history**

Relatives	Diagnosis	Age At Onset
Natural sister	Asthma	10

**Medications**

- Glurenorm(gliquidone)
- Amaryl(glimepiride)
- Daonil(glyburide)

**Vital Signs**

Date/Time	Dec 12, 2011
Body height measure	175.0cm
Body weight measure	70.0kg
Body mass index	23.0kg/m2
Self-monitoring of blood glucose	140.0mg/dl
Systolic blood pressure	140.0mmhg
Diastolic blood pressure	80.0mmhg

```

- <tbody>
- <tr>
  <td>Natural sister</td>
  <td>Asthma</td>
  <td>10</td>
</tr>
</tbody>
</table>
</text>
- <entry>
- <organizer classCode="CLUSTER" moodCode="EVN">
  <templateId root="2.16.840.1.113883.10.20.1.23"/>
  <statusCode code="completed"/>
- <subject>
- <relatedSubject classCode="PRS">
  <code code="73678001" codeSystem="2.16.840.1.113883.6.96" codeSystemName="SNOMED CT"
  displayName="Natural sister"/>
- <subject>
  <administrativeGenderCode code="F" codeSystem="2.16.840.1.113883.5.1"/>
  <birthTime value="1986"/>
</subject>
</relatedSubject>
</subject>
- <component>
- <observation classCode="OBS" moodCode="EVN">
  <templateId root="2.16.840.1.113883.10.20.1.22"/>
  <id root="b19dabc-783b-4bc2-aa55-48716858edaa"/>
  <code xsi:type="CE" code="ASSERTION" codeSystem="2.16.840.1.113883.5.4"/>
  <statusCode code="completed"/>
- <effectiveTime>
  <low value="1996"/>
  <high value=""/>
</effectiveTime>
  <value xsi:type="CD" code="195967001" codeSystem="2.16.840.1.113883.6.96"
  codeSystemName="SNOMED CT" displayName="Asthma"/>
</observation>
</component>
</organizer>
</entry>

```

Figure 14 CCD file

## 4.4 Web service

The SMS web service let our application send alter message to assigned case managers when user inputted vital signs value is abnormal. The web service can be called by our PHR application or the other application responsible for receiving message sent from the glucometers.

**SendSMSToCaseManagerByKOT**

測試

請嘗試 HTTP POST 檢核指定測試作業。請按「[Y](#)」或「[N](#)」按鈕。

參數	值
recvPhone:	<input type="text"/>
message:	<input type="text"/>

SOAP 1.1

下列是 SOAP 1.1 要求與回應的範例。請嘗試複製此處必須填入測試的這。

```
POST /MyHealthPortal/Services/SMSService.svc HTTP/1.1
Host: localhost
Content-Type: text/xml; charset=utf-8
Content-Length: length
SOAPAction: http://tempuri.org/SendSMSToCaseManagerByKOT

<?xml version='1.0' encoding='utf-8'?>
<soap:Envelope xmlns:xsi='http://www.w3.org/2001/XMLSchema-instance' xmlns:xsd='http://www.w3.org/2001/XMLSchema' xmlns:soap='http://schemas.xmlsoap.org/soap/envelope/'>
  <soap:Body>
    <SendSMSToCaseManagerByKOT xmlns='http://tempuri.org/'>
      <recvPhone>string</recvPhone>
      <message>string</message>
    </SendSMSToCaseManagerByKOT>
  </soap:Body>
</soap:Envelope>
```

HTTP/1.1 200 OK

```
Content-Type: text/xml; charset=utf-8
Content-Length: length

<?xml version='1.0' encoding='utf-8'?>
<soap:Envelope xmlns:xsi='http://www.w3.org/2001/XMLSchema-instance' xmlns:xsd='http://www.w3.org/2001/XMLSchema' xmlns:soap='http://schemas.xmlsoap.org/soap/envelope/'>
  <soap:Body>
    <SendSMSToCaseManagerByKOTResponse xmlns='http://tempuri.org/'>
      <SendSMSToCaseManagerByKOTResult>boolean</SendSMSToCaseManagerByKOTResult>
    </SendSMSToCaseManagerByKOTResponse>
  </soap:Body>
</soap:Envelope>
```

SOAP 1.2

下列是 SOAP 1.2 要求與回應的範例。請嘗試複製此處必須填入測試的這。

Figure 15 SMS web service

共有 10 筆資料 第一頁 上一頁 1 下一頁 最末頁 會員帳號: myhealthportalntu(陳煌仁)

序號	發送時間	接收號碼	姓名	訊息內容	點數	狀態
1	2011-12-07 14:31:57	0975805613		個管師您好! 您的個案 血糖過低數值為53 測量時間為12/07 14:31	1	已發送
2	2011-12-07 14:17:15	0975805612		個管師您好! 您的個案 收縮壓過高數值為159 測量時間為12/07 14:17	1	成功發送
3	2011-12-07 12:19:04	0975805613		個管師您好! 您的個案: 血糖過低數值為62 測量時間為12/07 12:19	1	已發送
4	2011-12-07 10:25:21	0975805612		個管師您好! 您的個案 收縮壓過高數值為161 測量時間為12/07 10:25	1	成功發送
5	2011-12-07 09:10:32	0975805613		個管師您好! 您的個案 血糖過低數值為62 測量時間為12/07 07:30	1	已發送

Figure 16 Alert messages

## Chapter 5 Discussion

Our approach here is to build an PHR application to assist users in self-management and activate users more engagement in their health care. So we review some papers and identify requirements as described in section 3.1 and finally implemented these requirements in our application. As shown on section 4, our application is a web based application, users can access or manage their data any time, and any place the internet connection is available. In the user interface, users can modify their demographic data (Figure 10) and update their diabetes notebook and most importantly to record their vital signs and health behaviors (Figure 11). According to these records, case managers can feedback user advices that may help users improve their health status and meanwhile educate users how to deal with some situations and thus improving user's health behavior (Figure 9). Our application can generate CCD document as a snapshot of user's health status that can be shared with care providers or family relatives, or as a standard clinical document for system interoperation (Figure 13). We offer the inner messages which allow users to asynchronously message to case managers about their problems of health or system usages. The patient education materials educate users how to deal with hypoglycemia or other situation, improving user's knowledge about diabetes. The commercial available glucometers our project provided, allow user to transmit the vital signs readings to our application right after

measuring manipulation through 3G telecommunications, thus is quite convenient for users without plugging in the device to internet or telephone network for data transfer.

## **5.1 Feedbacks**

Our application has been online since last September and serviced near 70 users. There are still some complains about our application, for instance, some users responded that the glucometer we provided were too large in size compared with other commercial available devices. When they went out either for work or fun, they preferred to use self-prepared small devices. Because the devices we offered were not merely a glucometer, which also consisted of other components such as blood pressure monitor and gateway. Many components resulted in larger size compared with other devices. We are still seeking other devices that are of small size also embedded with 3G telecommunication utility. For now, the alternative manner is allowing users to key in their glucometer readings and to submit to our server. Other complains include the bugs of our application and browser compatibility. Because our application is a web based application, and we want to let user smoothly manipulate their data, our application uses a lot of JavaScript either for input data validation or Ajax retrieving data between client and server. The JavaScript manipulation of DOM elements or CSS in different browsers may require different statements since they may not follow W3C standards especially

the older version browsers. In order to cross browsers, our approach uses the popular JavaScript library JQuery, through its API we can easily manipulate the DOM elements and bind events with them but the older version like (IE5, FireFox1 and Safari 2.0) are still not supported. Besides, the quick growth of Smartphone usage and its populations, user may use their Smart phones to access our application and manipulate their data. But the Smartphone embedded brewers are diverse according to the manufacturers or operation systems, which may amplify the browser compatibility problems. Our developers may consider offering an alternative mobile version for Smartphone users in the future.



## **5.2 Standards**

In order to quick offer services to users, our approach takes only three months to build the diabetes utilities, some design portions that were not carefully considered, such as the relationship of the emergency contactor to a user, just a textbox to let user key in, not a selection list to let user select, this results in the additional mapping of user entered text with the SNOMED CT Concept Name in the CCD generation process. The other is our diabetes notebook utility just copies the note's content to our application, results in information insufficient in the CCD generation process, for instance, the Medication section of the CCD composed of not only the medication list but also the



dosage and the frequency but the latter two components do not appear on the notebook.

The Rxnorm code system as a standardized nomenclature for prescription medications, we want to use it for document interoperability, but encounter some problems. The medication names the case managers offered to us and the name on the database of National Health Insurance Database cannot exactly match with the Rxnorm Concept Names, thus the Rxnorm API cannot find and return the exact Concept ID of the respected medication.

Table 2 Drug names comparison

ID	Name provide by CM	Name on NHIB DB	Rxnorm Concept Name
1	Amaryl (glimepiride)	AMARYL 2.0 TABLETS	glimepiride 2 MG Oral Tablet [Amaryl]
2	Glurenorm (gliquidone)	GLURENORM TABLETS 30MG	gliquidone 30 MG Oral Tablet
3	Actrapid HM	ACTRAPID 100 IU/ML	NO

We found three situations. First, we can manually find the exact Rxnorm Concept Name of medication (ID1). Second, we can find neither the brand name nor the generic name matched Rxnorm concept name, but we can find the matched generic name, so we just

use this one to represent that medication (ID2). Third, we cannot find any matched Rxnorm concept name (ID3), even uses the medication ingredient to search, there are no medications with that ingredient. Considering case managers are familiar with the names they provided, we still use that set of names but mapping them with the Rxnorm concept name when generating a CCD document.

### **5.3 Advantages**

Although there are still some complains and limitation on our application, our application still has some advantages. First, our approach hires case managers for monitoring user's health status, messaging and feedbacking advices to users. Some other approaches ask physicians to message or review journals patient made for office visit preparation results in physicians' resistance to use these kind of application [36, 37] since that will increase demands on their already limited time and lack of reimbursement. Second, in the development procedure we added case managers' viewpoint to our application, besides, the case managers have nice interaction with users so users will feedback them advices or complain upon our application. Our developing team can quick modify application in order to fit user's requirements. Third, although our CCD generation utility is only a prototype, we believe there are more comprehensive standards for health care system interoperation in the future and our

experience will benefit others in the development of a new telecare application.



## Chapter 6 Conclusion and Future Work

### 6.1 Conclusion

Our approach here is to help chronic patients like diabetes patients, to record their medication information, vital signs and behaviors, interact with case managers, and finally assist them in maintaining health lifestyle, since the disease is not curable and only can be improved through active self-management. We use ICT to build an application according to the requirements we identified from paper reviews and face to face discussions with the CMs. The result, users can access to our application and manipulate their data any time any where the internet is available, message with their case managers and generate the CCD file for sharing or interoperation. We also receive some user feedbacks about our application, either the device problems or the browser compatible problems that mentioned in section 5.1, the application will continually modify in order to fulfill user's requirements. Our application has been on-line just four months, it may need further evaluation about its efficiency and effect on improving user health status. On the other hand, our application adds other components in order to offer services to the other chronic diseases, like "COPD" (Chronic obstructive pulmonary disease) patients. Finally, we hope our experience will help developers to build a more complete and well designed PHR application.

## 6.2 Future work

Our application has some limitations as described in section 4. The standard implementation processes are not well designed which result in insufficient information collection and additional mapping work. Although our application can generate a CCD file for sharing user's health status and for interoperation purpose. But now it is just a prototype that retrieves data from our database to generate CCD file, in the future, it must allow to import the CCD file and insert respective data into our system. The growth of demands of accessing this kind of application by Smartphone or other portable devices will drive our team to develop a Smartphone compatible version in the future.



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