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Development of Service Systems to Support Diabetes Patient Self-management Using a Personalized Service Framework

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Abstract- patient self management is an important component in improving quality of chronic disease breathcare.The promising benefits of the interactive Behaviour Change Technology(IBCT) on diabetes patient self management are increasing recognized.In this paper, we describe a service framework and two service systems designed to support selfcare activities among type 2 diabetes patients: an automated telephone disease management(ATDM) service and a patient selft-management support portal.In chronic disease healthcare, enhancing patients' self- management can lead to enhancing user-co- creation and participation in the service system. The services to support patients' self- management must also focus on user customization, i.e. personalization, of the services. We describe a personalized service framework that coordinates the related data, knowledge, interactions and personalized services in facilitating patients' self-care. Finally, we discuss potentials of the proposed service systems to provide supplements and add-values to conventional healthcare service.

I.INTRODUCTION

Diabetesisaworldwideburden;itsprevalence isexpectedtoriseto366millionby2030Diabetes is a chronic disease which requires special attention both from healthcare providers and patients. Its treatment procedure is typically complicated and requires a lot of interactions between medical personnel and patients. However, due to the limited number of medical personnel and the increasing number of patients, the time and attention that the medical personnel canspendwitheachpatientbecomeslessandless.
From a last year statistics, the average time that a Thai diabetes patient has met with doctor wasless than 24 hours, which was clearly insufficient. Further, most diabetes patients are elderly people and working people who cannot conveniently travel to meet with their doctors regularly.In alleviating the problems, we propose uses of specialized technology to support self-management activitydiabetespatients.Supplement to Supplement to conventional healthcare, the servicesaredesignedtoimitatevirtualhomevisits to the patients using telephone and internet. They offer added services that are important for the patients especially while they are waiting for next visits to their doctors. The services aim toachieve four major goals. First is to assess patient's self-care. Second is to provide personalized recommendation. Third is to encourage and remind patient's self-care activities, such as exercises.Fourthistoscreenandmonitorforsome patient's critical conditions, such as medication overdose, disease complications, which require immediateintervention.

In this paper, we describe a service framework and service systems designed to support self-care activities among type-2 diabetes patients. The service framework consists of four layers: data, knowledge, interaction and personalized service models. We describe development of two service systemsthatcoordinatedtherelateddata,knowledge and interaction in providing personalized services for the patients. The first service system involves an automated telephone disease management service. The second service system involves a patient self-management support portal. Finally, we discuss potentialsoftheproposedservicesystemstoprovide supplements and add-values to conventional healthcareservice.

II.BACKGROUND

A. *Chronic CareModel*

The Chronic Care Model (CCM) is a guide to higherqualitychronicillnessmanagementinpatient care . The model recommends that improving six interrelated components -- self-management support, clinical information system, delivery system redesign, decision support, health care organization, and community resources -- can result in a more effective system in chronic care management. These components aim at producing more informed and knowledgeable patients and healthcare providers. This can result in more productive interactions between them and thus can potentially improve the quality of care and outcomes.

Self-management support is the component which focuses on encouraging patients to be knowledgeable about their illness and to be able to sufficiently look after themselves. Some key

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elements to this achievement include knowledge, motivation, self-efficacy, goal-setting, action planning and problem-solving.

B. *Self-management Support for DiabetesPatients*

Diabetes patients' daily lives are generally knowntohaveagreatimpactonthepatients'health. It is advocated that diabetes must be principally managedbythepatientonaday-to-daybasissuchas dietary habits (e.g., size and timing of meals, carbohydrate and saturated fat intake), increase in exercise (e.g. walking), intake of medications (correct dosage and timing as well as consistency over time), and monitoring of blood sugar levels, blood pressure, blood lipids, feet, and eyes. Unfortunately, self-management support occurs inconsistently during outpatient visits.

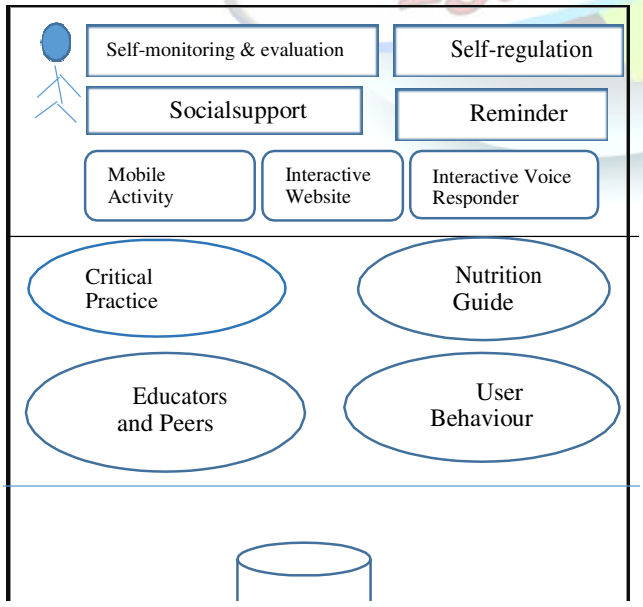
Effective diabetes self-management support requires a complex series of assessments and instructions. As a result, patients often require additionalsupportandcommunicationoutsideofthe traditional clinician visit.

III. RELATEDWORK

A. *Personalized ServiceFramework*

Although there are many diabetes self-management websites, few sites offered interactive assessments, social support or problem-solving assistance.Itwassuggestedthatthehelpfulnessand interactivity of these resources should be improved. One example of interactive diabetes patient portal was developed that linked to an existing electronic medical record system. The portal also provided patientswithpersonallogandcalculatorfordiabetes control, scheduling system and reminder, communications with the provider and other patients, and educational materials, and self-managementresources.

Architecture of a personalised service framework of PSMS



In our project, we adopt a personalized service approach which focuses on providing the patient's self-management process support, collaboration and personalization. A conceptual framework of the personalized service approach is shown in a layered architecture in Figure.1. The layered architecture composes of data, knowledge, interaction and personalized service models. Each layer is briefly described in the following sub-sections.

B. *DataModel*

The data model layer focuses on storing the patient profile, clinical and activity data. Patient clinical data such as hospital-based and lab test data can be obtained from the patient clinical data records. Patient daily activity data are recorded to allow monitoring, assessing and recommending based on the patient's behavior. The patients can entertheiractivitymeasurementobtainedfromsome measuringdevicessuchasastepcounterdevice,i.e. pedometer, minutes and calories measured by exercising machines as well as creating their meal records. Food and nutrition databases are necessary for further assessment and recommendation related to the patients'diets.

C. *KnowledgeModel*

Theknowledgemodellayerfocusesonacquiring and modeling knowledge required for patient's self-management. Such knowledge includes food and nutrition needs for the patients with different age, genderandtheirillnessconditionaswellastheirdiet preference. Medical guidelines such as clinical practice guideline (CPG) provides the knowledge related to recommended follow-up examinations, life style modifications and medications (correct dosage and timing) etc. The clinical guideline knowledge captured into machine processing form, such as ontology, will allow such knowledge to be applied to the data. In addition, diabetes patients often need friends to share and discuss their experiences.Communityresourcesareimportantfor the patients to motivate their behavior change. Educators can discuss with the patients to provide suggestions, and answer questions both in synchronous and asynchronous modes. Analytical processing of user activity data, e.g. user behavior analysis,canbeappliedtoimproverecommendation results. Further, recommendations that are provided based on the user's selected goals, barriers and strategies can help to encourage the user behavior change.

D. *InteractionModel*

IBCT usually relies on the following modalities: Website,E-mail,CD-ROM,PDAandIVR.Eachhas different advantages and disadvantages accordingto IBCT 5A's dimension.Thus, combining these modalities can complement each other in assisting thepatientselfmanagementcare.Interactionwiththe patients via IVR focuses on dialogue management.

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patientprofile,clinicalandactivitydata,andmedical knowledge. In generating new questions, the patient's previous answers and profiles should be taken into accounts. This will allow dynamic and personalized question generations that imitate human conversations. Interactive website should also be accessible by mobile devices which will allow the patient to conveniently input their daily activity data. Mobile sensors, such as pedometers, calorie burned meters, may be attached to the patient,e.g.totrackthepatientdailycaloriesburned.

E. Personalized ServiceModel

Our service model consists of five major personalized services: self-regulation, self-monitoring and assessment, social support, virtual home visit and reminder. Selfregulation is used as a dynamic motivational system of setting goals and developing strategies to achieve these goals. In self-monitoringandassessment,personallog,graphsand calculators are provided to estimate the patient's diabetes control. The social support function gives thepatientsopportunitiestocommunicatewithother patients with similar concerns or interests. Virtual home visits and reminders are system-initiated contact sessions, e.g. phone based questionnaires and SMSalerts.

Self-regulationisusedasadynamicmotivational system of setting goals, developing and enacting strategies to achieve these goals, appraising progress, and revising goals, developing and enacting strategies accordingly. Thus, this service provides interactive tools for setting reasonable and realistic goals, barriers and strategies as well as provides related knowledge for some selected strategies to encourage the user behaviorchange.

Self-monitoring and assessment of blood sugar levels, blood pressure, blood lipids, feet, and eyes are very important for diabetes patient. Personal logs, graphs and calculators should be provided for the patient to estimate his or her diabetes control.

Social support has been found to be a relevant factor in diabetes self-management. The social support function gives the patients opportunities to communicate with other patients with similar concerns or interests. The patients can utilize asynchronous communications, e.g. bulletin board, personal/ group mailboxes, to report their motivationalbehavior,caloriecountingandphysical activity. In addition, synchronous communications such as instant messaging or live chat systems can be utilized for more interactiveconversations.

In contrast to patient-initiated login sessions, virtual home visits and reminders are system-initiatedcontactsessions.Thevirtualhomevisitsare basically phone-based questionnaires supported by an IVR system. The system weekly contacts the patients based on the patients' chosen schedules. Eachweekthesystemwillcallandaskthequestions relatedtothepatients'pastweekdiets,activitiesand medication intakes, e.g. dosages, timing and consistency. One of the main purposes is to screen for some events which would require some urgent attentions. For example, when the patientfelt depressed or had not taken medications properly for some times, the system will notify the educators to promptly contact and talk to the patient.

The reminders, i.e. using SMS and/or e-mails, may be activated for several purposes. First is to remind and encourage the patient to logon to the system at some specified periods. Second is to remind and encourage the patient to perform tasks according to the action plan, e.g. records his or her weight, exercises, etc.

In the following sections, we describe development of two service systems that exemplified the framework adoption. Section 4 describes an automated telephone disease management service. Section 5 describes a personalized patient self-management support portal.

IV. AUTOMATED TELEPHONE DISEASE MANAGEMENTSERVICE

Telephone care programs are availablestrategies for bringing diabetes management services into patients' homes and improving their glycaemic control. Automated telephone disease management (ATDM) systems can augment telephone care by providing frequent monitoring and health education to large patient panels while allowing clinicians to focus attention on individuals who need it most. ATDM systems use specialized technology to deliver messages and collect information from patients using either their telephone's touch-tone keypadorvoice-recognitionsoftware.Findingsfrom multiple studies indicate that chronically ill patients will participate in ATDM and that the information they report during ATDM assessments is at least as reliable as information obtained via structured clinical interviews or medical record reviews. In some cases, patients are more inclined to report health problems during an automated assessment than directly to a clinician.

In this section, we describe design and interactions of an ATDM service prototype that supports diabetes patient selfcare activities.

1) Automated Call ManagementModule

This module involves setting up and configuring an IVR system. It initiates and manages outgoing callsessionsmadetoeachpatient.Thestatusofeach call is logged whether a phone conversation session has been terminated successfully or hung up prematurely. The information will help the call sessions to be reattempted in gathering the required information. The module also manages user

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authentication mechanism using phone number- password verification.

2) Call SchedulingModule

This module manages the patient-defined call schedules. The patient can interactively specify the timeslots that he or she intends to receive the phone calls each week. The patient can define timeslotsfor three types of phone calls: questionnaire (Q/A), system recommendation (SG) and self-learning knowledge resources (KM). The module also helps toidentifywhetherthetimeslotsareavailableforthe patient to select, i.e. all phone lines are occupied (red) or some phone lines are occupied (yellow). Thepatientcandefinealternatetimeslotsthatwillbe used when the call attempts failed during the intent timeslots.

3) Dialog ManagementModule

This module manages the system dialogs and interactionsbetweenthepatientandtheservice.The service utilizes Vaja[1] , a Thai text-to-speech software, in synthesizing audio clips from a dialog corpus.Theinteractionmodeliscreatedbasedonthe patient's clinical data, profiles, and medical knowledge.

V. DESCRIBESAPERSONALIZEDPATIENT SELF-MANAGEMENT SUPPORTPORTAL.

A. Design of Service System

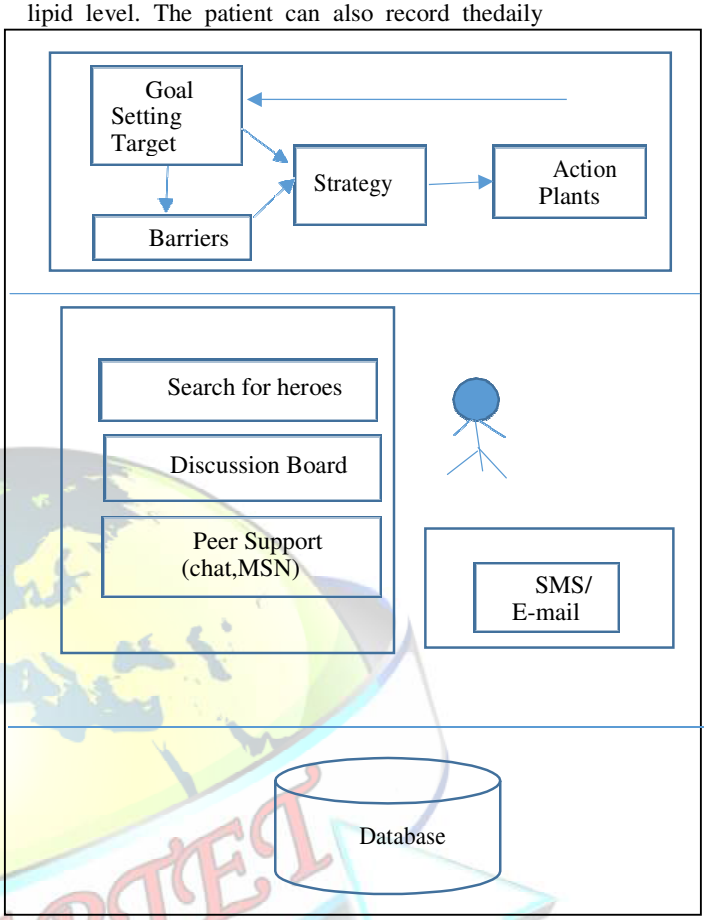
Designed functions of the portal can be grouped into five main services: providing self-regulation and management, self-monitoring and evaluation, social support, virtual home visit and reminder. In addition, the portal provides supported knowledge and tools related to the patient self-management. Some main functions of the portal prototype are summarized. The five support services are briefly described as follows.

1) Self-regulation andmanagement

The patient can log on to the system and set his or her targets and plans. The patient can set targets such as food control, weight control, exercises, foot care, etc. After setting the targets, the system shows list of possible barriers that may prevent the patient to achieve the targets . After the patient specifieshis or her barriers, the system shows recommended strategies that the patient can adopt to overcome the barriers. Further, each recommended strategy is associated with the related knowledge resources. Thepatientcancreatedailyactionplanonhisorher calendar as shown in Figure 7. This calendar is linked with the reminder service that can sendemail orSMStonotifyandencouragethepatienttofollow his or herplan.

2) Self-monitoring andevaluation

The patient can create his or her health records suchasweight,bloodsugarlevel,bloodpressureand lipid level. The patient can also record thedaily



activities, such as daily diets and exercise minutes. Thesystemwillprovidesupportedcalculationtools, e.g. food energy and exercise calories, and recommendations that help to support the patient self-care activities. The system can show personal and summarized health data to help the patient to monitor and assess his or her diabetes control performance. In addition, the patient can record and see reports of some major activities and milestones, e.g. changing targets, achieving the targets, visiting doctors, etc.

3) SocialSupport

Patientcancommunicatewithotherpatientswith similarconcernsorinterests.Thepatientcanposthis or her message on the discussion board or to other patients' private mailboxes. The portal allows the patienttosearchforotherpatientsinthesystem,e.g. based on patient profiles and performance records. In addition, patients with good performance records are automatically promoted as "heroes", who would be more visible to otherpatients.

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4) Reminder and Virtual HomeVisit

SMS and e-mail are automatically activated to encourageandremindthepatienttofollowhisorher action plan. In addition, the educator can monitor andrevieweachpatient'srecordtoassessthepatient performance. The educator can communicate with each patient by e-mail, SMS or make phone calls to give personalized recommendation and advice for eachpatient.

VI. DISCUSSION

Nowadays,nearlyanyonehasatelephone, either home phone or mobile phone. The automated telephone disease management service isexpectedtobeconvenientlyaccessibletoalarge number of patients. Although many diabetes patientsareelderlypeoplewhodonotcurrentlyuse Internet, the patient self-management support portal has many advantages, such as lowoperation cost and providing anywhere and anytime access for the patients. Further, increasingly more elderly peopleareusingInternetwhilemoreyoungpeople have diabetes. Thus, this service has a potential to becomemoreaccessibleforthepatientsinthenear future.

VII. FUTUREENHANCEMENT

Use voice and videocall

The challenge taken up by the healthcare community was to develop a high-quality, highly reliable, always-available system of interpretive services for hospitals covering languages most frequently spoken outside of English. Using Ciscoproducts and technology from other providers, it enables healthcare organizations to eliminate time, distance, and language as barriers toeffectivecommunicationbetweenclinicansand theirpatients.

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