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Medication Adherence for Patients with Mental Illness

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Abstract— **Medication adherence has been studied for some time; however most research has focused on able-bodied patients or the elderly living independently. What has not been studied nearly as much is medication adherence for people with psychiatric or mental illnesses. In this paper, we present a framework that includes the specific challenges in medication adherence for patients with mental illness, algorithms and protocols for evaluating adherence, and some on-going work in developing effective solutions. The architectural framework and associated algorithms leverage the context-aware computing capabilities available on many mobile devices. The system is designed to be able to collect and offer situation-aware information on medication use and adherence for healthcare professionals and other designated persons.**

I. Introduction

MEDICATION adherence has been studied extensively for able-bodied patients and the elderly living independently [1-5, 10]. Improvements in adherence are shown to reduce hospitalizations, improve patient outcomes, and reduce overall healthcare costs [6-9]. One of the most complex challenges is to study adherence for mental illnesses.

Medication adherence for mental illnesses is often lower than that for patients with physical illnesses because the consequences for stopping a medication are often delayed. Most physicians are not able to detect whether the lack of response is related to the medication regimen or to the lack of adherence. Also, patients with psychiatric illnesses that also have physical illnesses tend to have lower adherence than for both types of illnesses separately. More specifically, low adherence to anti-psychotic medication is a significant barrier to recovery in patients with serious mental illness [11]. We focus on medication adherence for schizophrenia and bipolar disorder, the two most complex mental illnesses [11, 15]. Increased rate of relapse and hospital readmission are associated with poor adherence to medications in both schizophrenia and bipolar disorder.

In general, very little adherence support is available from mobile devices and applications for patients with mental illness due to both system complexity and limited understanding of mental illnesses and their specific medication adherence requirements. In this paper, we present a framework for a system that supports multiple interventions for improving medication adherence for patients with mental illnesses, more specifically schizophrenia and bipolar disorder. Multiple interventions are likely to be more effective than single intervention for schizophrenia and bipolar disorders. Also, because patients with mental illness are as likely to use mobile devices as general population [21], real-time monitoring, notification and subsequent actions can help improve medication adherence without waiting for the next appointment. The system can be personalized for patients and by adding novelty factors into the software application medication adherence can be improved.

The paper is organized as follows. We present specific requirements of medication adherence for mental illnesses in section 2 and a framework for medication adherence in section 3. Next, in section 4, we describe the design of an application to collect and offer situation-aware information on medication use along with adaptive interventions. In section 5, we discuss why our approach is more suitable for patients with mental illness. Finally, some concluding remarks are provided in section 6.

II. Requirements of Medication Adherence

Our focus is on patients that are adults that live in independent living arrangements with or without a caregiver.

Monitoring of medication adherence has been ranked highly as a desirable intervention for psychiatric illnesses [11]. This fits in nicely as one of the objective measures of adherence [13]. Subjective measures, such as self-reporting or physician reporting, are often not reliable, so objective measures are frequently preferred for psychiatric illnesses.

When designing interventions, it is important to understand that many patients who are willing to take medication (attitude) do not necessarily take it (behavior). In order to design effective interventions, one must first address factors that are contributing to those problems [11]. This includes patient-related factors such as attitudes and past behaviors, demographic factors, environmental factors, cognitive impairment, and medication-related factors. Once the contributing factors are identified, then an appropriate and personalized strategy can be developed to address those problems.

The illnesses, adherence challenges, and a few potential interventions are shown in Table 1. Some specific examples of adherence challenges are (a) weight gain as a side effect, (b) sedation in bipolar disorder, (c) persistent positive or negative symptoms in schizophrenia, and (d) persistent grandiosity and manic symptoms in bipolar disorder.

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TABLE I
SEVERAL MENTAL ILLNESSES, SYMPTOMS AND TARGET POPULATION

Illness & Symptoms	Adherence Challenges	Interventions
Schizophrenia (Hallucinations and Delusions	1. Poor insight 2. Side effects 3. Efficacy with continued symptoms 4. Belief that medication not needed 5. Substance abuse 6. Cognitive deficits	Optimizing antipsychotic therapy Minimizing adverse events Using psycho-educational programs Treating substance abuse Involving family members Building good therapeutic alliances
Bipolar disorder (Manic phase followed by depressive phase)	1. Side effects 2. Belief that medication not needed 3. Poor insight 4. Efficacy with continued symptoms 5. Substance abuse 6. Problems with therapeutic alliance	Using individual psycho-educational programs and systematic care in "manic" phase Family therapy, cognitive-based therapy, and individual coping for "depressive" phase

The various factors affecting medication adherence can be classified as those affecting willingness and those affecting ability to take medication [11, 12]. The factors affecting willingness include negative attitude towards medication or belief that medication is not needed, lack of insight, lack of illness awareness, lack of efficacy (uncontrolled symptoms), poor therapeutic alliance, lack of family/social support, fear of side effects/addiction, and unmanageable/unacceptable side effects [11, 12]. The factors affecting the ability to take medications are cognitive deficits, substance abuse, disorganized environments, psychosocial issues, financial issues, housing problems including homelessness, lack of social support, resource and logistic problems, co-morbid psychiatric and medical conditions [11, 12].

Some requirements for an effective adherence system include the ability to: (a) work with mobile devices and applications, (b) collect and process persistent symptoms, (c) receive and sense side effects, (d) record and provide correct time and dose taken, (e) offer cognitive adaptation for the patient, (f) offer psychosocial education, (g) adjust and/or switch doses based on symptoms and side effects, (h) simplify medication regimen, and (i) switch to long-acting antipsychotic drugs, if needed.

III. A FRAMEWORK FOR MEDICATION ADHERENCE

We present a mobile solution for monitoring medications for patients with mental illnesses. We term such a system as a "Smart Psychiatric Medication System" (SPMS). One of the main requirements for this mobile application supporting the SPMS includes the ability to make medication adherence data available in real-time, and thus be wirelessly connected at all times. In addition, mobile phone applications are able to perform automatic data collection, including information about non-adherence, provide continuous patient monitoring because people have their smart phone with them all the time, and offer context-aware prompting by detecting user situations, recording user feedback, and providing an appropriate response via adaptive multimedia-based feedback to the patient. Other important design considerations include real-time medication reminders and the ability to accurately track a patient's location inside the home.

The architecture for the SPMS is shown in Figure 1, where an application running on a mobile device can interact with patient directly and can also communicate with external sensors. In some cases, the sensors on patient could include swallowing detection sensors [19, 20] or computer-controlled pill boxes to verify that the patient has taken the medication. This allows it to obtain both subjective (from patient) and objective assessment of adherence including timing, dose and pattern of medication use.

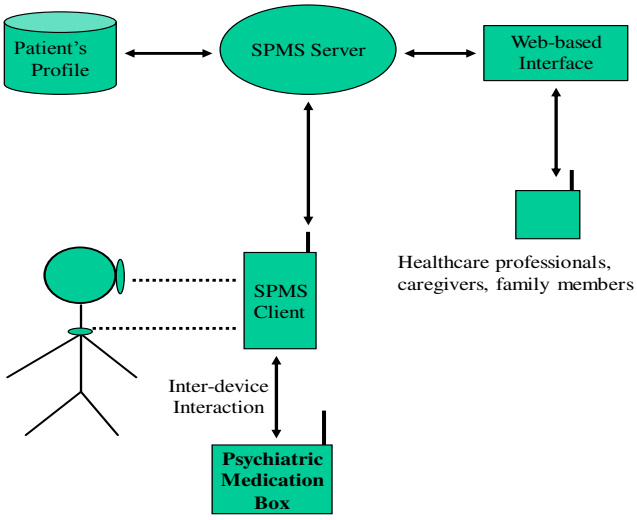

Fig 1. SPMS and Various Interactions

The application can decide, in cooperation with a healthcare professional, the type of intervention needed (Figure 2). The application can also communicate with a database server and healthcare professionals for adjusting medication doses or for simplifying medication regimen itself (Figure 3). Figure 2 shows specific actions related to shows adherence measurement and the generation of context-aware reminders. The SPMS notifies a healthcare professional if the number of reminders reaches some pre-determined threshold. Figure 3 shows the selection of suitable interventions based on multiple factors. The process continues until specific adherence goals are reached or the number of interventions tried exceeds some threshold, in which case a notification is generated for intervention by a healthcare professional.

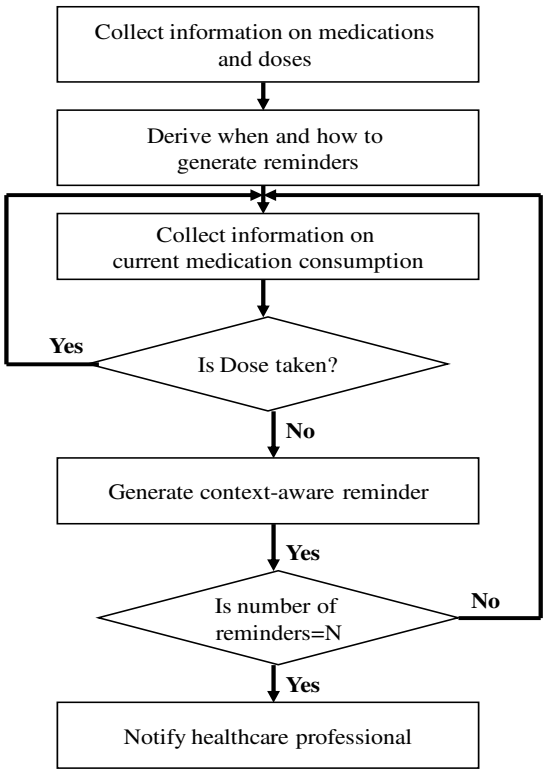

Fig. 2. Algorithmic Processing by the SPMS

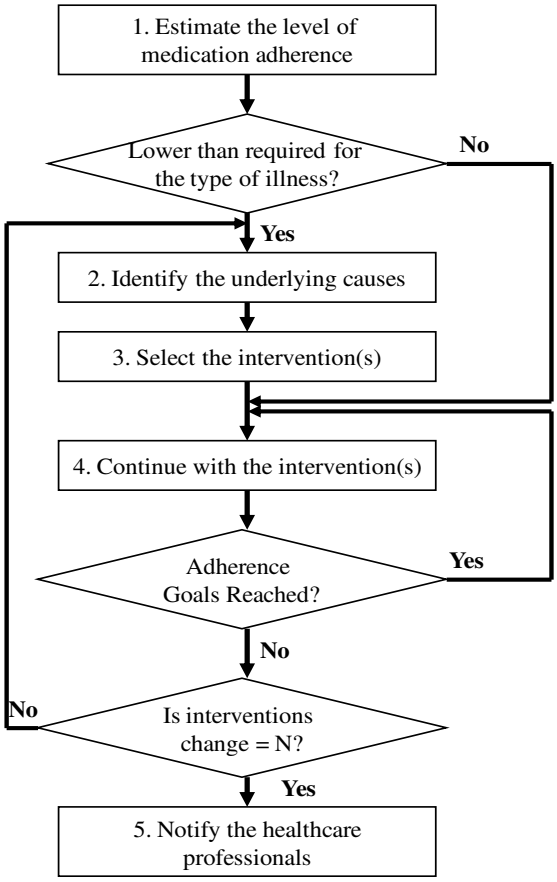

Fig. 3. Adherence Management by SPMS

IV. Design of Smart Psychiatric Medication System

This section includes several design components of the SPMS. One of the key aspects of the SPMS is the implementation of an effective medication schedule. It should be easy to understand at-a-glance and include safe and medically effective windows of time when the medication can be taken along with any inter-dependencies among multiple medications. Figure 4 depicts a medication schedule for four medications: A, B, C, and D along with an indication that medication A in the 6am-8am timeframe is inter-dependent with medication B in the 11am-1pm timeframe. This could imply that if the dose of A is not taken during 6am-8am, then dose of B must not be taken during 11am-1pm duration. Such a medication schedule can be described in an XML document and implemented as an interactive short message service (SMS) application [17]. An interactive SMS application is one in which state information is maintained between the client (phone) and server so that an on-going "conversation" is possible between repeated requests and responses.

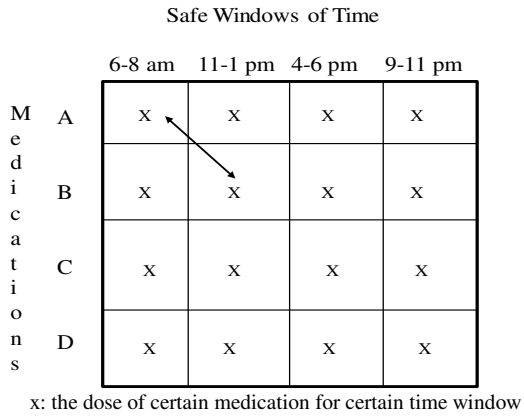

Fig. 4. Display of Medications Times, Status, and Inter-dependencies

We have implemented several SMS applications for a wide variety of services, including reminder systems, surveys and polls, educational learning trees, and drug trial prescreening [17, 18]. Although interactive SMS applications are useful, they are limited by text only. The advent of fully functional smart phones provides additional capabilities that enable the design of more effective applications that meet the requirements outlined in section II. Specifically, the SPMS client application can support (a) context-aware reminders/alerts, (b) at-a-glance medication schedules, (c) mobile education/training, (d) pre- and post-training assessment, (e) cognitive adaptation for the user, (f) the collection and processing of persistent symptoms, (g) multiple interventions involving multiple inputs, (h) wireless connectivity to sensors and the Internet, and (i) integration with the SPMS server and database. The basic structure follows the model-view-controller design pattern (Figure 5).

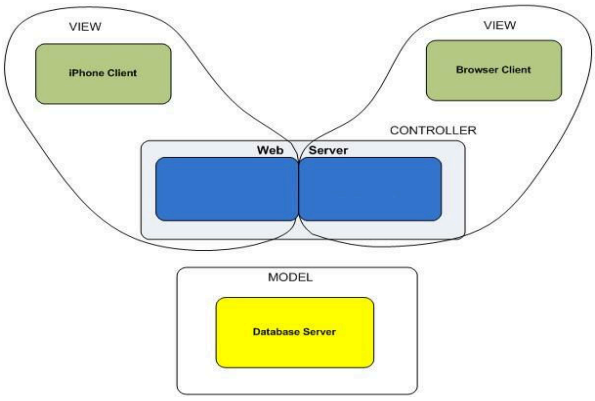

Fig. 5. Model-view-controller Design Pattern

V. DISCUSSION

Now we discuss why our approach is more suitable for medication adherence for patients with mental illness. The key arguments are:

- multiple interventions are more effective than single intervention for schizophrenia and bipolar disorders,
- patients with mental illness are as likely to use mobile devices as general population [21],
- real-time monitoring, notification and subsequent actions can help improve medication adherence for patients with mental illness without waiting for the next appointment,
- the application is personalized for the patients
- the ability to access information in a timely fashion and instant notification to healthcare worker and/or family members,
- novelty factors built into a mobile application can help to improve medication adherence, and
- support for situation awareness can also improve the effectiveness of multiple interventions.

VI. CONCLUSION & FUTURE RESEARCH

In this paper, we present a framework that includes the specific challenges in medication adherence for patients with mental illness, algorithms and protocols for evaluating adherence, and some on-going work in developing effective solutions. The solution is designed to be able to collect and offer situation-aware information on medication use for healthcare professionals and designated persons such as family members. Additionally, we are in the process of completing the development of the SPMS and planning a subsequent medication study with real patients. We hope that the proposed framework leads to addressing adherence challenges for patients with mental illnesses, including those affecting children and adolescents.

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