Strategies Towards Chronic Disease Management via Medication Compliance

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ABSTRACT

In the wake of the 21st century, healthcare systems around the globe are faced with an exponential rise in expenses, heavy utilization of services associated with a steep rise in aging population, and limited financial as well as human resources to manage the growing healthcare needs. Multiple studies in the past have noted the prevalence of chronic diseases in the aging population. Medicare's high-risk patients with five or more chronic diseases account for approximately 78% of all health care spending - well over a trillion dollar per year and/or over two-thirds of Medicare's annual spending. A large percentage of chronic diseases deteriorate to the point where a crisis is reached resulting in unnecessary long-term hospitalization at massive cost to the healthcare sector. A critical inference drawn from epidemiological data and past studies is that preventing occurrences of acute episodes holds the key to providing quality healthcare, reducing incidences of prolonged hospitalizations and resultant healthcare expenses. This research is a work-in-progress that seeks to explore innovative strategies towards promoting medication compliance among chronic patients. This paper discusses the need for medication compliance and the cost of non-compliance to the healthcare sector. Salient behavioral, organizational, and technical research issues, opportunities, and challenges associated with promoting medication compliance via communication, computing, and sensing technologies are discussed. Potential benefits and costs of deploying innovative IT based medication compliance are also presented.

Keywords:

Medication compliance, prescription errors, information communication technologies, healthcare, chronic disease management, healthcare costs.

INTRODUCTION

In the wake of the 21st century, healthcare systems around the globe are plagued by exponential rise in expenses. The current healthcare expenses in US are approximately 15% of the GNP [18] and projected to reach 17% of the GNP by 2011 [2]. Another trend observed parallel to the rising healthcare costs is the "graying of the globe" - the worldwide population of adults over 65 years of age is on the rise and is expected to reach 761 million by 2025 [20]. Multiple studies in the past have noted the prevalence of chronic illnesses in the aging population. Chronic illnesses require long term treatment/monitoring and strict compliance with doctors' recommendations, failure of which can lead to complications, unnecessary hospitalizations at huge costs, and fatal consequences. Seven of the most prevalent chronic illnesses in U.S. (and their associated in-patient expenses) include: coronary artery diseases ($25.6 billion), heart failure ($15.2 billion), chronic obstructive pulmonary diseases ($6.2 billion), mental health disorders ($3.9 billion), diabetes ($3.8 billion), hypertension ($3.2 billion) and asthma ($1 billion) [6]. Medicare's high-risk patients, approximately 8 million currently, with five or more chronic diseases account for approximately 78% of all health care spending - well over a trillion dollar annually and/or over two-thirds of Medicare's annual spending [1, 2, 3].

Many healthcare experts agree that current Medicare expense patterns are a reflection of chronic illnesses managed unsuccessfully [2]. A large percentage of chronic illnesses deteriorate to the point where a crisis is reached resulting in unnecessary long-term hospitalization at massive cost to the healthcare sector. A critical inference drawn from epidemiological data and past studies is that preventing occurrences of acute episodes holds the key to providing quality healthcare, reducing incidences of prolonged hospitalizations and resultant healthcare expenses [19]. In order to reduce preventable acute episodes from occurring, it is critical to focus on preclusion of crisis/complications, proactive management of chronic illnesses, timely detection of anomalies, and provision of

medical assistance without time and/or locational constraints such that patients can lead a normal, healthy lifestyle outside of the hospitals.

Chronic illnesses (e.g., diabetes, asthma) are vastly different on many fronts from short term illnesses (e.g., cold/cough, influenza, fracture). Medication compliance with respect to chronic illnesses is a necessity towards reducing unnecessary hospitalizations, associated train on human as well as financial resources, and maintaining a sense of wellness among chronic patients. Table1 outlines some of the key differences which affect disease management of chronic versus short-term illnesses.

Illnesses	Chronic Illnesses	Short Term Illnesses
Fact	Although not limited to but is found to be prevalent among the aging population, who may suffer from multiple chronic diseases.	The population for short term illnesses ranges from an infant to adults including senior citizens
Cure	Non-Curable – No known cure to chronic illnesses such as diabetes, hypertension etc. Hence focus is on *promoting wellness via managing illness*	Curable – Can be cured via medications, surgeries etc. Few examples include: influenza, broken bone, typhoid. Hence focus is on *curing illness*
Clause	Persistent treatment and adherence to medical advice is key to managing chronic illnesses and alleviating complications and associated hospitalizations	Relatively shorter treatment time and adherence to medical advice is required to alleviating symptoms and curing the illness
Expenses	Accounts for *approximately 80%* of all healthcare spending by Medicare	Accounts for a much smaller proportion of annual healthcare spending
Goal	Goal is *preclusion of complications* in order to *successfully manage chronic illnesses* and to reduce unnecessary health expenses	Goal is to cure the illness
Strategy	Compliance to medication is critical in maintaining a sense of wellness	Compliance to medication is critical in curing the illness

Table 1: Chronic Illnesses versus Short term Illnesses

This research is a work-in-progress that seeks to investigate medication compliance as a strategy towards successful management of chronic illnesses. IT based medication compliance is a key piece of the healthcare puzzle and has the potential to make immense difference in personalized healthcare delivery and practice. The research contributions are:

- Modeling salient characteristics of medication compliance, categories of medication compliance, and associated challenges (Section 2)
- Presenting an overview of the current state of research with respect to medication compliance (Section 2)
- Articulating the underlying process towards an integrated framework for IT based medication compliance and directions for future research (Section 3)

AN OVERVIEW OF MEDICATION COMPLIANCE

The practice of using medications to curing illnesses has been part of healthcare since time in memoriam. Before the arrival of modern medicine, plant extracts and herbs and were widely used to treat and cure illnesses. In the past the challenge has been on finding medications to cure an illness. At the turn of the 21st century healthcare sector is faced with the challenge of managing chronic illnesses. A critical piece of the solution lies with medication compliance, i.e., taking the correct dosage of the correct medication at the correct time by the correct person for as long as directed by a medical professional. This seemingly simple and innocent process has been found to be the perpetrator of numerous complications and colossal expenses.

With the number of US prescriptions filled in 2006 reaching to 2.4 billion, the cost for prescription medications is a major component of healthcare expenses. It would be acceptable if all the medications prescribed

and bought were used for intended purposes. However, the use of medications ranges from no-use (about one third), infrequent use (about one third), and overuse to abuse (about one third). The non-adherence to medications leads to more than 125,000 deaths in the US and more than $90 billion in additional hospitalization and procedures every year [4]. Additionally, people who miss their doses are three times more likely to see doctors again, resulting in further increase in healthcare expenses. According to NIH [5], about 20% of the people in the US have used prescription drugs for non-medical reasons, also known as prescription drug abuse. This further increases the cost of healthcare including the need for additional medications. Table 2. categorizes non-compliance with respect to medications and presents the challenges associated with each category.

Non-Compliance	Intended Non-Compliance	Un-Intended Non-Compliance
Description	Intentionally not complying with medications resulting in over use and/or under use of medications. Examples: patients tampering with certain medications such as morphine for personal reasons rather than medical	Unintentionally not complying with medications resulting in over use and/or under use of medications. Example: patients forgetting to take medications as directed resulting in missed dosages and/or making up for missed dosages by combining two dosages
Consequence	Secondary complications, unnecessary hospitalizations at massive expenses, fatalities	Secondary complications, unnecessary hospitalizations at massive expenses, fatalities
Strategy	Affecting attitude and behavioral changes via creating awareness, education, guidance, and penalty/reward for behavioral choices	Setting up reminders and/or alerts in order to confirm to medications. Dispensing the correct amount of medication as and when required to the right person

Table 2. Compliance Categories and Challenges

Promoting Medication Compliance

To address the above challenges, there has been some work towards increasing the medication adherence. The current literature on IT based medication compliance has mostly focused on patients who fall under the category of unintended non-compliant. Most interventions for adherence fall into three categories:

1. Educational: Information conveyed verbally and in writing to patients
2. Behavioral: reminders, contracts, drug packaging
3. Affective: Counseling, home visits, and family support.

These interventions have helped improving the adherence, but it is still not satisfactory. The key challenges in medication adherence are (a) some patients not getting their prescriptions filled, (b) some of the patients who are getting their prescription filled are using it infrequently or discontinuing at will and (c) some are using "catch-up" to take an overdose for compensating missed dosages. Healthcare Information Technologies (HIT), especially wireless and mobile technologies, can address some of these challenges. Even a small improvement in the adherence to medications can save millions of precious healthcare dollars everyday. To identify and use these technologies, there is a need to study and model these challenges and technologies and then to derive and design technology-based solutions for enhancing adherence [17].

Medication management has been done by patients and family members for long time in several different ad hoc ways. These could range from using sticky notes, organization of medicines, and reminders. There has been some work on studying how elders manage their medications currently and how such methods may be incorporated in future assistive technologies for medication adherence [15]. More specifically, an ethnographic study has identified that some elders devise medication management systems using the spatial features of their homes, their daily routines, and how and when they visit certain places in their house to help remember them to take their medications [15]. The study also presents several principles for the design of assistive technologies for future personalized medication systems.

TECHNOLOGY BASED MEDICATION COMPLIANCE

Recently, computing, communication, and sensing technologies have been employed for supporting medication management, enhancing adherence to medications, reducing misuse and abuse, and reminding patients to take their medications at certain times. Most technology based medication management systems have been implementation via a pill container (Figure 1) with alarms that go-off at certain times and the pill container remembers how many times it has been opened and closed. Such reminders along with reminders from family members and healthcare professionals could increase the compliance to medications, especially for patients with cognitive and/or physical disabilities. An example is Magic Medicine Cabinet (MMC), designed to enable reminding and ensuring to take the right medicine, measure vital signs, inform about conditions, and interact with healthcare professionals [14]. The MMC uses both voice and embedded display for reminders to a patient. It employs Internet connectivity, face recognition, RFID-based smart labels, vital sign monitors, touch-sensitive screen, and voice synthesis for reminders [14]. Another example is smart medicine cabinet designed to support mobile and young patients with chronic diseases [16]. The features include use of reminders, query for contents (medications), expiry date detection, and alarms for product recalls. The system utilizes both passive and active RFID tags to monitor medication boxes and to communicate with a cell phone, respectively.

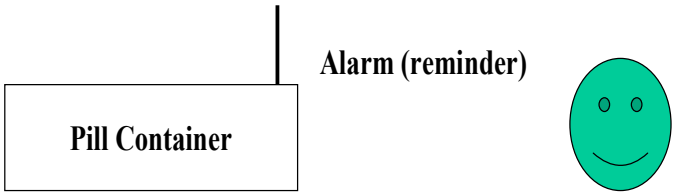

Fig. 1. Basic Medication Management System

There are many advantages of such medication systems. These include improvement in adherence level resulting in better utilization of already occurred healthcare expenses, reduced number of hospitalizations, and better health outcomes including reduced morbidity, reduced mortality, and improved quality of life. Overall, the medication management system could lead to reduction in both existing healthcare cost of prescriptions and future healthcare cost of treating patients for a lack of health improvement [17].

There are several potential disadvantages of medication systems. These include potential for reduced adherence if the medication management system is very restrictive and inflexible, the total cost of medication management system including the hardware and software cost, and, difficulty in use with changes in patient's or healthcare professional's schedule and travel. Also, such system may fail or could become inaccessible for some reason, resulting in a patient missing an important dose. To avoid this, medication systems should support switching to a manual mode of operation in case of failure or other problems. Other backup measures may also be in order to help patient comply with medications [17].

Underlying Process Towards an Integrated Architecture for Medication Compliance

One way to reduce medication abuse is by only allowing prescribed medication to be dispensed with certain doses at a certain number of times a day to certain people. This medication system can also keep track of the time and the number of times/day a certain medication was taken. Also, it can keep track of how many times a patient attempted to open the medication system without success. Physicians can check/communicate with the medication system on medication adherence and/or abuse before renewing the prescriptions. The following describes the underlying process towards developing an architectural framework that seeks to enhance medication compliance:

1. Authenticating the Patient
   - Sensing to authorize the right personnel to access the medication
   - Based on biosensors, RFID, password etc.
   - Locking out after "X" number of unsuccessful attempts

- Password reset by authorized medical personnel

2. Authenticating Correct Medication
   - Ensuring correct medication depending on patients' identity time
3. Authenticating Correct Dosage
   - Dispensing the precise amount of dosage
   - Alleviates the issue of over use and/or under use
4. Authenticating Correct Time
   - Dispensing medication as directed based on the number of times to be taken in a 24 hour period
   - Reminders based on sound, text, visual aid, and/or a combination
5. Ensuring Fault Tolerance
   - Alerts and/or reminder for missed dosages
   - Not allowing over dosage
6. Alerting for Potential Adverse Events
   - If the medication dosage has been missed despite of reminders, and missed dosages are above the threshold, notify authorities

CONCLUSION AND FUTURE RESEARCH

Ultimately, our objective is to develop an integrated architectural framework for a system that leverages computing, communication, and sensing technology to promote medication compliance specifically among chronic patients who are categorized as non-intended non-compliant. The system will not only house compliance specific data but will also collect other information such as hospitalizations. The data collected by the proposed system can be computationally modeled to analyze and predict the potential of an adverse event. The integration of the proposed system with an EMR will provide the physicians with a holistic view of the patients' behavior outside of the hospitals. The analytical capabilities of the system will allow the physicians to deliver personalized evidence based healthcare to the patients. The projected benefits and costs of IT based medication compliance strategy interfacing with EMR will also be discussed.

Integrating the data collected in the proposed process with an existing EMR can provide a holistic view to the physicians with respect to evidence based personalized delivery of healthcare to patients. Both the promises and opportunities associated towards that end are colossal. Some of the potential challenges are:

1. Technical – The technical challenges pertain to the specific technology utilized for promoting medication compliance, ensuring security and privacy of collected data, etc.

2. Behavioral – The behavioral challenges pertain to issues associated with trust of the users in the proposed processes, attitude of the potential users, behavior and adoption etc.

3. Organizational/Political – Healthcare is a highly regulated environment thus mediation compliance needs to be maintain strict confirmation with federal regulations such as HIPAA, ARRA etc. Additionally, there are constraints with respect to other stakeholders such as insurance companies, physicians/other caregivers, pharmacy etc. to buy into the utility of the proposed processes.

The current manuscript sets the stage to addressing some of the aforementioned challenges and addressing the ultimate goal of developing an integrated research framework for medication compliance.

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