Chapter 12
Smart Medication Management, Current Technologies, and Future Directions

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ABSTRACT

Medication non-adherence is a major healthcare challenge with irreversible consequences in terms of healthcare costs and quality of care. While recent years have seen some effort in developing sensor-based technologies to detect medication adherence and provide interventions, the community lacks a comprehensive study on the clinical utility, reliability, and effectiveness of such medication intake monitoring solutions. Furthermore, many opportunities inspired machine learning algorithms have largely remained unexplored. In an effort to highlight these knowledge gaps, in this paper, we take an interdisciplinary approach to (1) review and compare existing engineering products for medication intake monitoring; (2) discuss clinical applications where such technologies have demonstrated to be effective; (3) explore research gaps and shed light on unmet needs and future research opportunities in the area of medication management from both clinical and technology development points of view. The results of this paper may open several new avenues in the area of technology-based medication.

INTRODUCTION

Insufficient medication adherence is a big problem in medical field and contributes significantly to healthcare costs and poor quality of care, in particular in patients with chronic conditions. Studies show that medical prescriptions are never filled in almost 20% to 30% of the cases. Furthermore, 50% of medicines are not taken as prescribed for chronic patients (WHO, 2003), (Viswanathan et al., 2012).

DOI: 10.4018/978-1-5225-0920-2.ch012

Of all medication-related hospitalizations in the US, 33% to 69% are as a result of patient's insufficient adherence to prescribed medication (Lüscher & Vetter, 1990), which annually costs about $100 billion to $289 billion (Viswanathan et al., 2012). The consequences of medication non-adherence are enormous. In the United States, more than 10% of hospitalizations, approximately 125,000 deaths, and a substantial growth in morbidity and mortality are due to medication non-adherence. For example, studies show if the patients fill no discharge medications by 120 days after a post-acute myocardial infarction, the probability of death at 1 year will increase 80% (Jackevicius, Li, & Tu, 2008).

Improving medication adherence can potentially influence large patient populations and result in significant cost savings. Each American adult has at least one chronic illness and currently 75% of the total cost of healthcare accounts for patients with one or more chronic conditions (Chisholm-Burns & Spivey, 2012). Average adherence to medication in chronic illnesses is generally higher than that of acute diseases (Jackevicius, Mamdani, & Tu, 2002). As an example, half of the patients with acute coronary syndromes discontinue to take hydroxymethylglutaryl–coenzyme six months after they start therapy (Lüscher & Vetter, 1990). These observations show that novel clinical and technological approaches are needed to enhance medication adherence which will significantly decrease the costs associated with poor adherence in patients with chronic conditions.

According to 2003 report of World Health Organization (WHO) (WHO, 2003), interventions could be deployed to improve medication adherence in patients with chronic diseases, such as asthma, heart failure, diabetes. Technological advancement in intervention methods results in higher rate and improving assessing methods of adherence. Electronic intervention and monitoring approaches such as mobile and wireless technologies, electronic sensors, and web portals are developing very fast and aim to provide patients and healthcare providers with a potential rapid and organized form of gathering, manipulating, and analyzing adherence patterns with customized reports to enhance medication adherence behaviors. Taking advantages of technology in medication adherence is not only useful for patients' health, but also can be utilized by clinicians and researchers to improve their clinical decisions, development strategies, and methods of intervention.

With the recent advancements in electronics, sensor design, communications, and data analytics, we can potentially develop novel technological approaches to objectively monitor patients, assess their medication adherence, and provide effective and timely interventions. While recent years have seen some effort in developing sensor-based technologies such as wireless electronic pillboxes to detect medication adherence and provide interventions, the community lacks a comprehensive study on the clinical utility, reliability, and effectiveness of current such medication intake monitoring solutions. Furthermore, many opportunities inspired by computational models such as signal processing and machine learning algorithms have largely remained unexplored. In fact, the literature is lacking a comprehensive study of existing technology-related medication adherence solutions, an analysis of advantages and shortcomings of the state-of-the-art technologies, a study of promises that these systems provide, and future directions in this research area. In an effort to highlight these knowledge gaps, in this paper, we take an interdisciplinary approach to

1. Review and compare existing engineering products for medication intake monitoring;
2. Discuss clinical applications where such technologies have demonstrated to be effective;
3. Explore research gaps and shed light on unmet needs and future research opportunities in the area of medication management from both clinical and technology development points of view.