Evaluating Reminders for Medication Adherence and Side Effects in M-Health Environment

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ABSTRACT

Reminders are a very promising intervention for improving medication adherence in mobile health environment. From the published literature, this research find that effectiveness of reminders varies widely and side effects of reminders have not been studied. To address these, this article develops an analytical model to evaluate different types of reminders for medication adherence. The model is also used to estimate side effects of the reminders. The results indicate that context-aware reminders perform better than simple reminders in improving medication adherence for willing patients in mobile health environment. Simple and persistent reminders also lead to more side effects than context-aware reminders. The results of this study will be useful for patients, healthcare providers, researchers and policy makers in improved decision making for medication adherence. The future work can include development of smart reminders to meet different requirements of patients, healthcare professionals and payers in terms of personalization, performance, long-term effectiveness, reliability, and health outcomes.

KEYWORDS

Analytical Model, Medication Adherence, Mobile Health, Performance Evaluation, Reminders

INTRODUCTION

Medication nonadherence leads to significant cost burden on healthcare systems (Cutler, Fernandez-Llimos, Frommer, Benrimoj, & Garcia-Cardenas, 2018). Not taking medications as prescribed, is a common, complex, and costly problem that contributes to undesirable treatment outcomes. An estimated healthcare expenses of $100-$300 billion per year in the US is due to medication nonadherence (Cutler et al., 2018; NEHI, 2009). According to the World Health Organization (Sabate, 2007), medication nonadherence needs to be addressed globally to improve the quality and reduce the cost of healthcare. Reducing the medication nonadherence for chronic diseases (Rajan, Seidmann, & Dorsey, 2013; Santo et al., 2017) alone could result in a 1:10 cost-to-savings ratio (Sabate, 2007). Medication nonadherence can be intentional, where the patient actively chooses to deviate from the treatment regimen, or unintentional, where the patient is forgetful in adhering to the regimen.

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In healthcare literature, several interventions to improve medication adherence have been proposed (Choi, Lim, Kim, & Park, 2008; Kim, Combs, Downs, & Tillman III, 2018; Krebs et al., 2015; Maulucci & Somerville, 2011; McDonald, Garg, & Haynes, 2002; Oswald, 2018; Schreier et al., 2013) including those based on reminders. Although very promising, we find from a detailed analysis of the published literature that effectiveness of reminders varies widely and side effects of reminders and healthcare costs (Lokshina & Lanting, 2018) have not been addressed. Further in almost all of the evaluations of interventions, Average Medication Adherence (AMA), as the ratio of doses consumed to doses prescribed (Osterberg & Blaschke, 2005), is the predominantly used measure. Although a useful metric, different patients could achieve the same AMA with widely different consumption patterns and can have different health outcomes. Therefore, there is a need for objective measures to detect adherence improvements (Nieuwlaat et al., 2014). Recently, a single metric, termed Effective Medication Adherence (EMA), has been proposed to capture both the time gaps between doses and Average Medication Adherence (Varshney & Singh, 2013). EMA can indicate what fraction of doses is taken within the medically effective time interval. This is a better predictor of health outcomes than AMA alone. Further, the values of EMA over time can represent the pattern of medication adherence of the patient as steady, improving or declining at different rates (Varshney & Singh, 2013). The side effects, in terms of Undesirable Dose Events (UDE), where the patient is taking medications with less than medically safe time gap, needs to be evaluated also for different types of reminders.

**Research Questions**

The research question we address in this study are:

**RQ:** How to evaluate reminders for Effective Medication Adherence (EMA) and Undesirable Dose Events (UDE)?

RQ is addressed in Section 3 as part of evaluation using set of Lemmas (1-6) and Propositions (1-3)

**Research Approach and Results**

Our results show context-aware reminders outperform simple and persistent reminders in improving EMA for willing patients. The side effects, in terms of Undesirable Dose Events (UDE), where the patient is taking medications with less than medically safe time gap, are also higher for simple and persistent reminders.

**Contributions and Organization of the Paper**

The evaluation of reminders can help decision makers at multiple levels: starting from the patients to take their medications more regularly, to healthcare providers in better managing their patient outcomes, and to hospitals in meeting various government regulations on patients’ admissions and readmissions.

The paper is organized as follows. In next section, we present some background on reminders as intervention for medication adherence and identify the major limitations of the literature. Then, in section 3, the reminders are evaluated using an analytical model and then results on adherence and side effects are discussed further. In section 4, we present and discuss some observations. Finally, we make some concluding remarks and present possibilities for future research.

**BACKGROUND AND REMINDERS AS INTERVENTION**

In this section, we present reasons behind medication nonadherence, various interventions that have been proposed and a literature survey of studies on reminders as an intervention.
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