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Smart Interventions for Opioid Abuse: Design and Evaluation

Neetu Singh, University of Illinois Springfield, USA*
Upkar Varshney, Georgia State University, USA

ABSTRACT

The number of people in the US with opioid abuse exceeds two million, and the total cost is approximately $100B per year. There is a need for smart interventions that can lead to better outcomes for patients and reduce the need for healthcare resources. In this study, the authors present three smart interventions for patients: (a) mobile reminders, (b) electronic monitoring, and (c) composite intervention. More specifically, the authors present a design approach for smart interventions and operationalize the interventions. They have developed an analytical model for evaluating interventions. Interventions are cost-effective for higher values of intervention effectiveness, hospital, and emergency room cost. However, with quality-of-life (QoL) improvement, cost-effectiveness improves significantly. The authors also explored the use of financial incentives for increasing the adoption of interventions. These results will help patients, healthcare professionals, decision-makers, and family members to choose the most suitable intervention to address opioid abuse.

KEYWORDS

analytical model, evaluation, Opioid abuse, patient level, smart interventions

INTRODUCTION

Prescription opioid abuse is any intentional use of opioids outside of a physician's prescription for a bona fide medical condition (Finley et al., 2017; Lossio-Ventura, Song, Sainlaire, Dykes, & Hernandez-Boussard, 2022; Sarker, DeRoos, & Perrone, 2020; Sinha, Jensen, Mullin, & Elkin, 2017). It can lead to addiction, higher healthcare costs, and serious harm to patients (Azadfard, Huecker, & Leaming, 2022; Blendon & Benson, 2018). This abuse requires detoxification and hospitalization very similar to a chronic condition. The number of people in the US with opioid abuse exceeds 2 million and the total cost is approximately $100B per year (NIH, 2019). According to NIH, about half of the drug overdose deaths in the US are due to opioids (NIH, 2019) and resulted in 80,816 deaths in 2021 (CDC, 2022). Opioid abuse is a major challenge for patients and family members, healthcare professionals, employers, regulators, and society. There is a need for smart interventions at multiple levels before patients develop opioid addiction and require major treatment (Singh & Varshney, 2019a,

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2020; Varshney & Singh, 2020b, 2020c). These smart interventions can lead to better outcomes for patients and reduce the need for healthcare resources.

Each patient has a certain chance of abusing opioids (single vs multiple prescriptions) based on their history, genetic makeup, current environment, medical condition, and type of opioid prescribed. Some of the patients will have low, some moderate and some will have a high level of opioid abuse. This is also time-dependent, and patients can change from low to moderate to high or high to moderate. This has some chance of leading to addiction, which will require expensive inpatient treatment. This abuse should be considered a chronic disease and different patients will require outpatient treatment for different durations of time. A different set of actions will be needed (a) at the source (for healthcare professionals) managing the prescriptions, (b) patient-level during consumption of opioids, and (c) after the patient has developed an addiction. In this paper, we focus on patient-level interventions, which are proactive and with some probabilities will be effective for some patients in preventing them from developing an opioid addiction. To design smart interventions, we present a design approach. Using multiple constraints and considering the environmental context, we have developed three smart interventions. The interventions are (a) mobile reminders (Voelker, 2019), (b) electronic monitoring of opioids (Jungquist et al., 2019), and (c) composite intervention (monitoring, reminders and support from other patients) (Schuman-Olivier et al., 2018; Varshney, 2015). The mobile reminders will be sent to the patient to provide educational and motivational support to avoid overconsumption of opioids. Electronic monitoring will keep track of the prescribed opioids. This involves designing wireless monitoring systems for collecting and analyzing opioid consumption data. The composite intervention will include reminder, monitoring and motivational support from other patients. This intervention can reduce the consumption of prescription opioids by monitoring and reminding patients about taking and/or not taking certain doses within certain windows of time. The interventions can be implemented using both simple and sophisticated mobile apps, sensors, mobile devices, and smart medication boxes. This could proactively stop patients from becoming dependent on opioids or developing an addiction.

Using prescription opioid abuse and intervention data, we derive the healthcare cost of opioid abuse along with the cost of three interventions. Using an analytical model and ROI (Return on Investment) as a metric for the cost-effectiveness of interventions, we derive several results for all three interventions and various levels of effectiveness. We found that ROI is lower than 1 for low and medium values of our parameters, while it is much more favorable when the values of the parameters are set to high. When the value due to a potential improvement in Quality-of-Life (QoL) was included, the ROI significantly improved for all three interventions. Further, we wanted to explore if the use of financial incentives will be suitable to improve the adoption of three interventions. For this, we computed the maximum allowed financial incentives that can be offered to the patients while still meeting the cost-effectiveness goal for the interventions.

The paper is formatted as follows. The design approach is presented in the next section followed by interventions design and operations. Further, the analytical model is developed to evaluate the smart interventions and is followed by results. Finally, the discussion and conclusion including the future work is presented at the end.

DESIGN APPROACH

The design of technological intervention starts with the identification of the environmental factors, patient's condition, and medical history followed by possible solutions. These include communication with and notification to patients, observing consumption behavior, providing individual/group education and support, analyzing patterns of opioid consumption, and providing cognitive behavior therapy. To make these interventions more effective we add context-awareness and refer to these as smart interventions (Singh & Varshney, 2019b). The interventions can be in the form of a mobile app implementing reminders, monitoring, and support functions. These interventions can be single or