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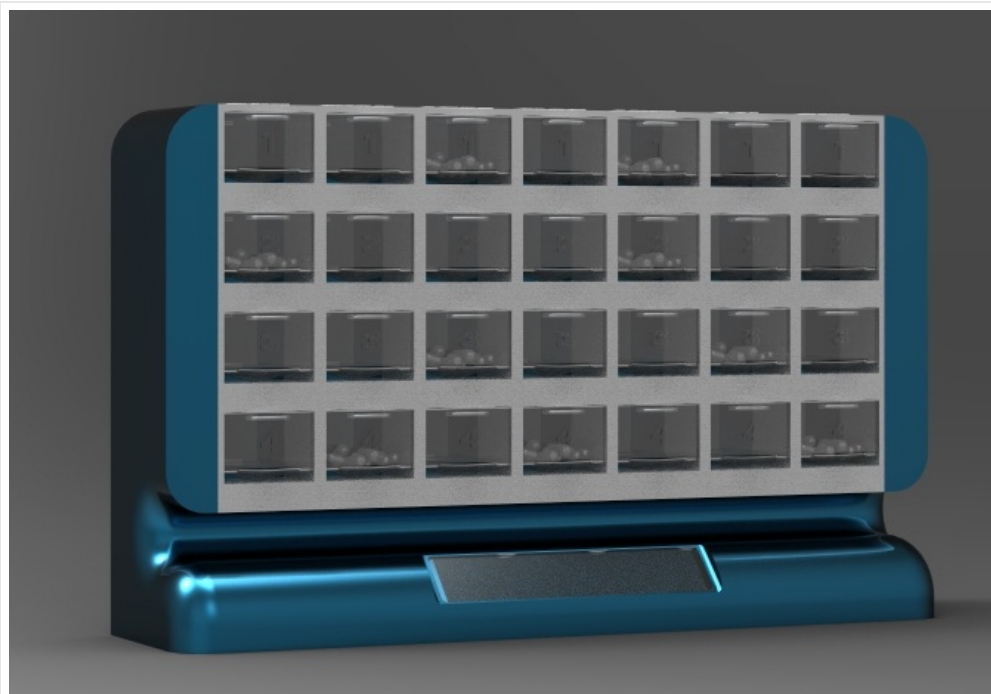


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The Smart Pill Box (University of Alberta)

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The Smart Pill Box

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ABSTRACT

Statistics currently show that medication adherence is a significant problem in the healthcare system. To improve medication adherence we developed The Smart Pillbox, with a web-based application and mobile application to help patients take their medications. The device addresses the functional issues of adherence, portability, monitoring, notification, and cleaning.

INTRODUCTION

Medication adherence is a significant problem the healthcare system currently faces. Roughly 50% of patients with chronic illnesses do not take their medications as prescribed. [1] Poor medication adherence can increase morbidity and death in patients. It has been estimated that poor medication adherence costs the United States \$100 billion per year. [2] In the World Health Organization's 2003 report [3], Adherence to long-term therapies, evidence for action, Haynes [4] was quoted that "increasing the effectiveness of adherence interventions may have a far greater impact on the health of the population than any improvement in specific medical treatments."

According to Statistics Canada [5], the average Canadian, in 2005, had 14 prescriptions for that year and Canadians between the ages of 60 and 79 had 35 prescriptions in 2005. Canadians, 80 years and older, received on average 74 prescriptions in 2005. Over 75% of individuals over 65 years of age are prescribed prescription medications and they take three or more medications per day. [6] Reach [7] states that:

The information that a patient must remember in order to take just one pill is actually complex and is made up of seven properties: the name of the drug, for which disease it is used, how to take it, the number of daily intakes, when to take it (before, during, or after a meal), dosage, and duration of the treatment.

The complexity of medication regimens and the pill burden patients face impacts medication adherence.

BACKGROUND

There are a few different devices that are widely available to patients to aid in medication adherence. Dosettes are commonly used by patients and are offered in a variety of sizes and dosing schedules. However, dosettes can be confusing to fill and their basic design offers no notification or monitoring features and they are rarely cleaned by their users. Blister packaging is available at most pharmacies and patients with complex medication schedules or high pill burdens often use this service. Blister packaging ensures that the medication is correctly scheduled for a patient, but does not guarantee adherence. Patients do not receive notifications to take their medication and therefore the patient must remember to take their medication. Individuals with arthritic hands may find it hard to remove the pills from the blister cards and this could negatively affect adherence.

MedSignals® is a medication device that is currently on the market. [8] It is designed with four bins (one bin per pill type) and is programmed to provide notifications to the user at scheduled times. It monitors medication adherence by monitoring when a door to a bin is opened. Problems with the MedSignals® device were found when the device was tested with two patients at the Glenrose Rehabilitation Hospital. The bins were small, which made it difficult for individuals to remove the medication from the bin. It was difficult to program the device and the device only allowed for four medications. The monitoring of the device was inaccurate, because the patient opened the bin's doors multiple times because of pill spillage and confusion. Finally, the design of the device was counter-intuitive. The patient had to open multiple bins to remove their scheduled pills for a particular dosage time.

DESIGN OBJECTIVE

The purpose of this interdisciplinary project was to develop a medication device that increased medication compliance, monitored medication taking behavior, and communicated with patients, caregivers, and pharmacists.

METHODS / APPROACH

The team started the design process by researching current medication devices. After looking at the limitations of each device, we composed a list of key features/ objectives we thought were essential to include in our design. Our design needed to be intuitive, user friendly, simple, flexible, and portable. The design needed to be able to notify the user, monitor the user's medication adherence and the device would be for scheduled oral medication. The device needed to have one bin per dosage time, rather than one bin per pill type. With these features/objectives in mind, we started to develop designs. We used research and simple experiments to develop our design. The team carefully debated each detail to include in our design.

The Design

We designed *The Smart Pill Box* device to help patients be adherent to their medications. The device addresses the functional issues of adherence, portability, monitoring, notification, and cleaning. The device consists of 24 chambers that are placed in 7 columns made up of 4 rows, as seen in Figure 1. The 7 columns represent the 7 days of the week and the 4 rows represent 4 different dosage times in a day. The device is organized to have one chamber per dosage time. Therefore, each chamber represents a dosage time for a particular day. The user is able to use as many of the 24 chambers as they need in order to accommodate their medication schedule. Each chamber is made with UV resistant transparent plastic to allow the user to see the medication and the LED light that is behind each chamber acts as a notification signal to the user. The LED light will illuminate when it is the time for the user to take medication from a particular pill chamber (Figure 3). The UV transparent plastic will also protect any medication that is degraded by UV light. Each chamber has a number written on its door to help identify the dosage time (Figure 1). On the top of each column, the days of the week are displayed and they are also displayed on the top of the pill box's frame (Figure 1).

A screen is located at the base of the pill box to display notifications to the user. At the base of each chamber, there is a shelf that houses the chamber's ambient light sensors. The shelves also act as anchors to clip in the columns. The LED light located behind each chamber also provides the light source for the ambient light sensor. As seen in Figure 3, each chamber has an indent at the bottom of the chamber to allow the medication to accumulate over the sensor. The ambient light sensor is able to detect the light when the pills are removed from the chamber. This sensor therefore monitors the medication adherence of the user. If the user does not take their medication, the sensor will not detect the ambient light and therefore will record that the medication was not taken.

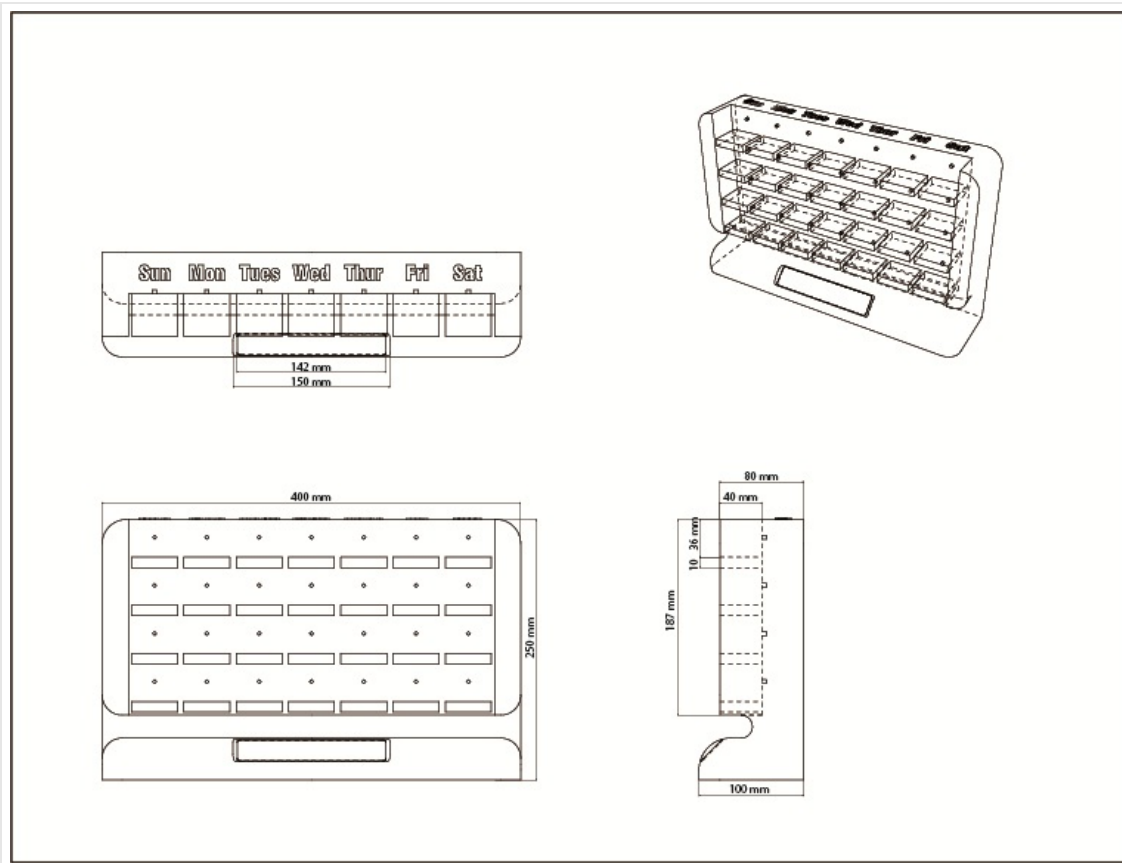


Figure 1: Orthographic diagram of The Smart Pill Box.



Figure 2: A 3-D image of The Smart Pill Box with a column removed.

The pill box has a space located underneath each column, which allows the user to grasp the column to easily remove it. Each column can be removed from the frame of the pill box if the user is going out for the day or travelling (Figure 2). The user places his/her hand underneath and on top of the column and pulls the column forward. The columns can also be removed for cleaning. The columns are dishwasher safe and the doors of each chamber can be locked open to allow for easier cleaning. The Smart Pill Box can be laid down horizontally to allow the user/pharmacist/caregiver to easily fill each chamber with medication. The pill box can be plugged into a power outlet to receive power and it also has a backup battery in case of a power outage.

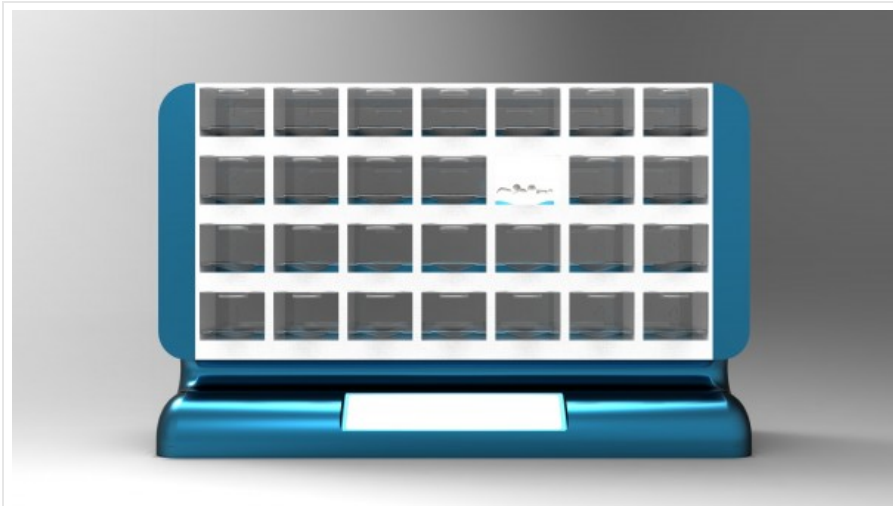


Figure 3: A 3-D image of The Smart Pill Box with a chamber illuminated.



Figure 4: A removed column of The Smart Pill Box.

The Application

The application is a web-based application that uses Wi-Fi for communications between the device and the application. The pharmacist/caregiver/user can program the pill box by using a confidential and secure web-based application. Medication,

dosing schedules, and instructions are entered into the calendar-like interface of the application (Figure 5). The application can be programmed so that the user, caregiver, and/or pharmacist receive notifications from the application. Once the scheduling is completed, the information is pushed to the mobile application and the pill box. The pill box is then filled by the user/pharmacist/caregiver based on the schedule created on the application.

In an everyday scenario, the appropriate chamber will begin to glow at the scheduled time and a notification will be sent to the mobile device(s). The user opens the chamber and takes the medication as directed by the pill box's screen and the mobile application. The ambient-light sensor detects if the pills have been removed. This information is recorded and time-stamped by the application. If the user does not take their medication and the advised time period elapses, the medication will be recorded as "missed" and an alert will be sent to the user and the caregiver. The caregiver can contact the patient to investigate further why the medication was not taken.

When the user disengages a column, when they are going out for the day or travelling, the application receives notice of the disengaged status and will send a notification to the caregiver. When the column is disengaged, the sensors and LED light are not attached to the column and therefore they will not work. The mobile application will still be functional and will alert the patient when they need to take their medication. The labeling on the column and the directions on the mobile application will direct the patient to the correct chamber to find the correct medication for each dosage time. When the column is placed back into the pill box, the sensors will detect if the medication has or has not been taken and they will record this information. The application will send notifications to the mobile application and to the pill box to warn the user that it is time to refill or clean the pill box. The user/pharmacist/caregiver can set the timing of these warnings.

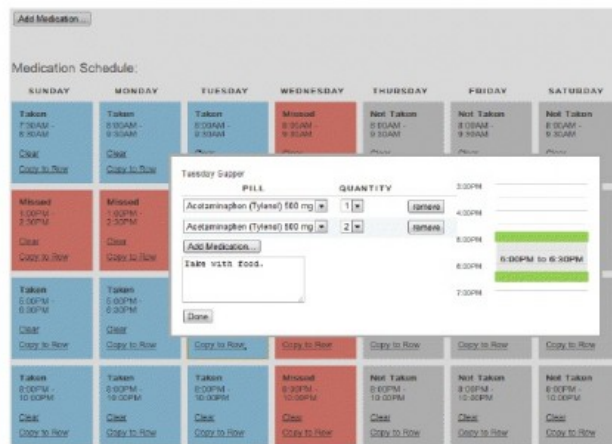


Figure 3. Editing a bin in web application

Figure 4: A removed column of The Smart Pill Box

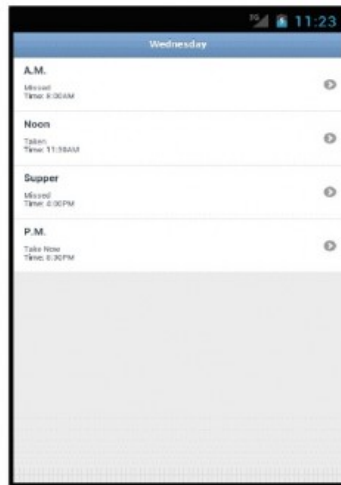


Figure 5 Daily schedule view on mobile application

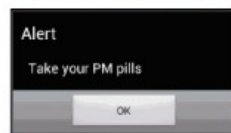


Figure 6 Mobile application notification

Figure 6: Daily schedule view on the mobile application.

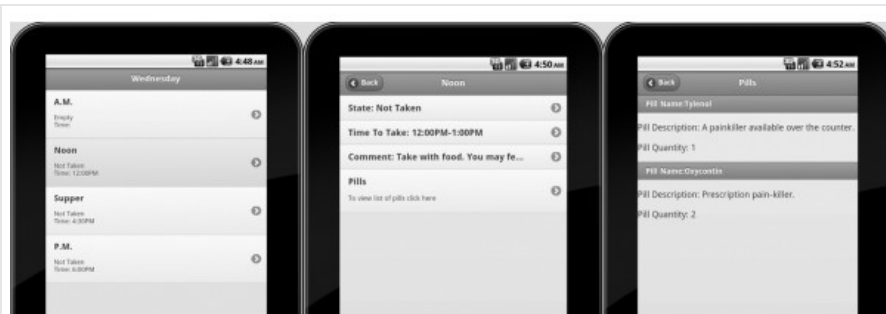


Figure 7: The daily view (left), the details view (center), and the information view (right)

DISCUSSION / OUTCOMES / PERFORMANCE/ IMPLICATIONS

The Smart Pill Box incorporates universal design features. The pill box is customizable for different individual preferences. Also, it is flexible with different medication schedules and can be programmed based on the individual's medication schedule. The design of the pill box is simple and intuitive. The pill box is designed to look like a calendar to make its use more intuitive. The chambers of the pill box were designed to accommodate a wide variety of finger sizes, which makes it effortless for individuals to remove their medications.

With an aging population, medication adherence will continue to be an issue and the pill box can help increase patient adherence. According to Industry Canada [9] in 2006, 72% of Canadians aged 35-54 years own a cellphone and 48% of Canadians aged 55 years and older own a cellphone. These statistics show the feasibility of using a mobile application to aid in notifying a patient to take their medication. The baby-boomer population is fairly comfortable using a variety of technologies. Currently and as this population continues to age, we hope they will become more comfortable with using technology to assist them in taking their medication. Involving caregivers and pharmacists in the function of the pill box really helps give patients the support and care that they need to take their medication and adds a social component to the device. We hope that the interactive and flexible features of the pill box translate into patient uptake of the device.

Testing has been completed with The Smart Pill Box's sensors and the web based application. Further research is needed to evaluate more precisely the effectiveness of The Smart Pill Box. Testing with different segments of the population is needed to assess individual interactions with the device and to measure medication adherence.

ACKNOWLEDGEMENTS

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