Development of Intelligent Pharmaceutical Packaging for Real-Time Monitoring of Patient Compliance

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Purpose

To develop a device that allows real-time reporting of medication administration to specified individuals involved in the patient's care.

Background

In clinical practice, patient compliance is defined as the extent to which a person's behavior coincides with medical or health advice[2]. It has been estimated that 50-55% of children and their families do not follow treatment plans as prescribed[1]. For example in the United States, it is estimated that only 30% of patients have adequate control of their blood pressure[3]. As the effectiveness of the prescribed therapy depends heavily on the patient's ability to properly follow and adhere to their prescribed therapy, patients who fail to comply to their medication regimen often experience higher incidence of relapse, morbidity, mortality, and an increase in frequency of re-hospitalization; all of which contribute to increase health care costs.

In this work we describe a new device that uses customizable circuits to allow real time monitoring and enforcement of patient medication adherence with single dose resolution.

Materials and Methods

The circuit prototype was constructed by exploiting the intrinsic electrical properties of a conductive material such as graphite. A model circuit was applied onto a paper substrate in such a way as to represent the dimensions of a blister pack (Fig. 1). Graphite circuit tracks were broken on the paper surface to simulate removal of a dose. Resistance values were measured across a given circuit and plotted as a function of disrupted circuit tracks.

Materials and Methods

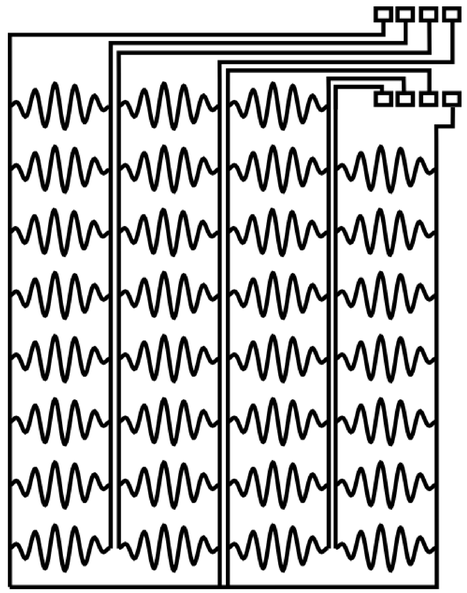


Figure 1: Circuit design

Circuit Integration: Circuits were developed on paper substrate above. A microcontroller was used to monitor the circuit and communicate with a remote server. Circuit tracks were disrupted to simulate dose removal. Server Sent Events were used to communicate medication dispensing events to the remote server.

Web Integration: A web service was created which would allow healthcare providers (HCPs) to create patient profiles. Within each profile the HCP has the option to set patient contacts as well as methods of contact such as text, email or social network. Within the patients profile, a HCP can assign a device to a particular patient and assign a medication (Fig. 2). Dosing instructions for each medication/device are specified and used to make reminder/notification decisions.

Notifications and Logging: Software running on the remote computer monitors and records each medication event as it is transmitted from the microcontroller in real-time. In this example a separate program can be used to scan the database to check for scheduled medications.

Materials and Methods

If a medication is scheduled and no event has been recorded, the computer can be instructed to send notifications to contacts specified in the patient profile (for example, other approved HCPs). Medication event histories for each device and patient are stored and can be used to assess adherence.

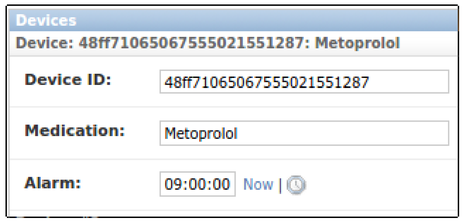
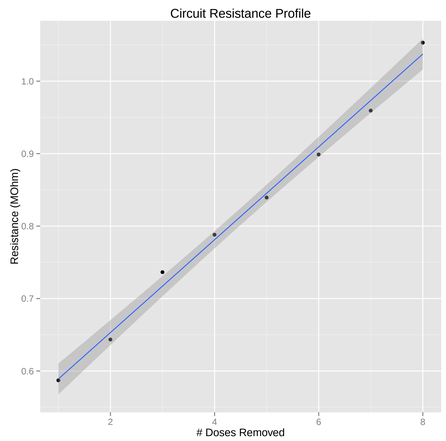


Figure 2: Linking patient and medication to device.

Results and Discussion

The circuit design was such that each successive dosage removal increased the total resistance of the circuit. The microcontroller interpreted this change in resistance as an event and sent a signal to the remote server for recording. Several circuit designs were tested before selecting one which demonstrated a linear increase in resistance with each removed dose. Circuit resistance was measured using a digital multimeter and plotted as a function of "doses" removed (Fig. 3). This linear response is ideal as it provides a robust and predictable indicator of dosage removal, although any predictable configuration is possible when designing the circuit.



Conclusion

The circuit design indicated is suitable or use with microcontrollers which would allow dose removal to be recorded or reported to a central computer or server. The circuit design allows each medication dose to be monitored as it is removed from a standard blister pack. In fact, any type of single dose unit medication dispenser could be modified in this way. Data could be stored locally with a time and date stamp for each dose of medicine taken, or it could be transmitted in real-time to a remote computer for storage. Additionally, data could be used to send updates/notifications to HCPs involved in the patient's health regarding medication usage.

References

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Acknowledgements

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