An Inhaler Dose Recording Service Designed for Patients Who Need Chronic Respiratory Disease Control

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Abstract. The paper introduces a completely integrated and developed care cycle for patients with chronic respiratory disease who need to take inhaler drugs twice a day. Because patients may simply forget to take an inhaler dose or take the wrong inhaler medication. Inconsistent and mistaken inhaler medications may cause problems for diseases control. The system contains a main website for medical experts and caregivers to manage patients' health information from clinics. It also provides an off-site APP that allows patients to download the program to their mobile phones to monitor the inhaler dose they should be using. The APP connects to a smart inhaler device that has been patented in Taiwan. In this study, we implemented it as a cap for the metered dose in the medicine cylinder for the first experimental stage. We randomly selected 16 patients with asthma for the prototype face-to-face usage interview. Feedback from users was significantly positive.

1 Introduction

The World Health Organization (WHO) reports that the worldwide mortality rate from lower respiratory infections has rapidly increased [1]. During the past few years, we have used Internet Communication Technology (ICT) to create and deploy a few system platforms for pulmonary disease care management for asthma, chronic obstructive pulmonary disease (COPD), etc. [2–4].

Our experience with such systems indicates that physicians and caregivers are usually satisfied with the outcomes of using them; nevertheless, collecting historical data on medicine taken and inhaler doses missed is difficult. Inhalation medications often contain drugs that taking overdoses or under-doses of might jeopardize a patient's health, for example, steroid and bronchodilator components for asthma and COPD. In practice, many patients often do not precisely comply with physicians' recommendations. For example, patients might not regularly use prescribed medications, because they are afraid of the side effects, or they might simply forget. Additionally, our experimental experience tells us that at least 70 % of patients need follow-up education to ensure that they properly comply with their prescribed medical regimen. In other cases, some patients might not remember the last time they took the medication, and so they might unnecessarily repeat a dose.

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Other studies report that mistakenly using the wrong inhaler drug might cause a patient's condition to worsen. Approximately 4–9 % of patients who use inhalers do so incorrectly [5, 6]. Moreover, misusing metered doses might also unnecessarily increase medical expenses: "…this applies equally to metered dose inhalers and dry powder inhalers and leads to poor disease control and increased healthcare costs" [7].

At present, many inhaler medicines show the number of doses (baseline maximum and number of doses taken) on the container (e.g., "60/120"), and once a medicine dose is taken, the metered counter number decreases by 1. Physicians normally recommend that patients take their prescribed medication at a certain frequency, e.g., twice a day. Thus, a dose inhaler with 60 doses per fill can be used for as long as 1 month.

Our goal in this experiment was to provide patients taking inhaler medications an easy-to-use method for correctly using their inhalers. Using the current ICT method and the Internet of Things (IOT) concept, we implemented a service called "MDP" (metered-dose plus) as a smartphone plug-in subsystem that contains both APP software and a cap device (Fig. 1). To design a convenient and extendable service that records the number of inhaler doses taken supports consistent and safe drug use by patients. We hope that this kind of system will not only improve patient health because it efficiently monitors and reminds patients of their correct drug doses and frequencies, but also suggests to manufacturers to consider in greater detail how to develop inhalers and other commercial personal drug delivery systems that are significantly more user-friendly.

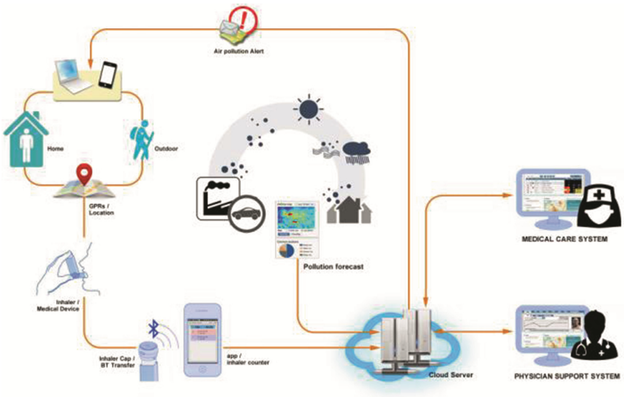

Fig. 1. The complete workflow of service for our MDP chronic respiratory pulmonary disease care platform.

2 Methods

The technology of high-tech devices is changing rapidly, and the mobility functions of devices connected using sensors and wireless access to the Internet or a private network have blossomed in today's market [8]. A systematic platform also becomes part of an information platform that allows data mining and analysis in the current health-conscious climate [9–11]. "A mobile patient monitoring system [uses] mobile computing and wireless communication technologies [to measure and analyze the] biosignals of a mobile patient. In [many trials,] these systems have [proved to be user-friendly, convenient, and effective, both for] patients and [for] healthcare professionals" [12]. Mobility, as in "mobile APPs", is becoming a key for the healthcare industry, not only for controlling disease, but also for being a reminder of healthcare activities, like taking one's medications on time, and for being a safety monitor [13].

2.1 System Architecture

The MDP incorporates three major components: a remote server, a mobile application, and a smart inhaler. The user-enabled application (APP) provides end-to-end service for disease control, and it computes and stores corresponding data on remote servers. The inhaler is paired automatically with the APP via a BLE GATT service. Once the inhaler is triggered, data with a pre-defined BLE service and characteristics are extracted by the application as a dosage record.

Glossary:

- COMM: Communication Block for HTTP/Socket data handling.
- UI: Mobile User Interface for care service delivery flow.
- Engine: Back-end computing and management module.
- Database: Relational database of user data.
- API: Application Program Interface for capturing remote data.
- BLE: Bluetooth 4.0 Low Energy protocol.
- BLE GATT: BLE Generic Attribute Profile defining corresponding BLE data schema and service (Fig. 2).

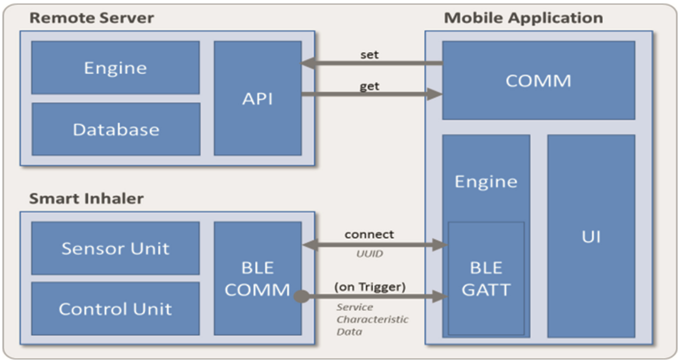

Fig. 2. The system architecture of MDP service.

2.2 MDP Prototype Description

The MDP service provides alerts, records, and easy-to-submit functional information, like the patient's posture, the time an inhaler dose was taken, and the number of doses left in the patient's medication container. Moreover, if an incorrect dose is taken, a red-light alert will show on the cap device to warn the patient of the error. When the patient is using the dose inhaler, a start circuit is initiated to detect the time the inhaler dose is taken. When the patient presses the inhaler's trigger, a sensor chip determines whether the pressure exceeds the acceptable threshold, a timer generates time data, a counter generates frequency data, and a memory chip simultaneously stores and submits the data.

3 Results

The MDP service provided a total mobile and web solution both for patients and for physicians, and it rendered the following benefits: increased patient dose compliance and life-style control; made patients more aware of their disease control progression; gave them a greater understanding of how to control their disease; established a synchronized information-sharing connection between the patient and their physicians; and increased the effectiveness of their current treatment. These are all qualitative judgments, of course.

The MDP device could be recycled simply by unplugging it from the used inhalant. The cap helped physicians (i) better understand and evaluate each patient's personal progress using specific medication, (ii) proactively rectify patient doses, (iii) build up each patient's self-awareness and knowledge of medication and patient health, and (iv) subsequently improved their quality of life (Fig. 3).

Fig. 3. The output of the prototype MDP service.

4 Discussion and Conclusions

Sixteen patients who were taking inhaler medicine were selected to participate in the experiment and to express their opinions of the development of the MDP service. Thirteen (81 %) of the 16 patients were satisfied with the service. A second trial can be planned for the near future to test the MDP service for at least 3-6 months with randomly selected patients who have been diagnosed with appropriate respiratory diseases (asthma or COPD).

We also learned from the Internet, that there is a similar device now on the market that retails for US$39.99 [14]. This device stores data on an individual item without wireless access or data analysis feedback messages. The smart inhaler device contains a BLE chip, which makes it expensive; therefore, how to improve the user interface and reduce the price of the device will be our next challenge.

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