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# A Mobile Logbook to Diagnose Masked Hypertension: a Pilot Application

Claudio ECCHER<sup>a,1</sup>, Maria BOTTERI<sup>b</sup>, Daniele ORTOLANI<sup>b</sup>, Stefano FORTI<sup>a</sup>, Enrico Maria PIRAS<sup>a</sup>

<sup>a</sup>Fondazione Bruno Kessler, Trento, Italy <sup>b</sup>Scuola di Formazione Specifica in Medicina Generale, Trento, Italy

Abstract. In the last years, there has been a growing interest in health mobile applications. Great benefits could be gained by seemingly "simple" solutions if these were designed to build a bridge between doctors and patients. In this paper, we describe a mobile health solution for patients allowing them to measure and record accurately their blood pressure at home, helping doctors to diagnose hypertension. An accurate measurement of the blood pressure, in fact, is a prerequisite for appropriate management of hypertension, a condition causing many serious diseases. The peculiarity of the hypertension kit is that the system requires interaction between the patients and their general practitioner. Finally, we present a pilot study carried out to evaluate the acceptability of the technologies, the compliance of patient to the self-monitoring procedure and the perceived benefits and disadvantages of both doctor and patients in using this kit.

Keywords. M-health, hypertension, Personal Health Record, NFC.

## Introduction

In the last years, there has been a bloom of health related mobile applications. This relatively new market has been hailed by many as a potential game changer in the relationships among health institutions and patients, providing the latter with the tools for empowerment and self-management. The large success of mobile health applications, though, is now mostly limited to the self-care practices with only limited connections to the clinical processes. This is partly due to the gap existing between the relative easiness in designing of health applications for patients and the complexities of rethinking clinical processes to fully exploit the potential of m-health applications and to explore new forms of technologically enhanced patienthood characterized, among other things, by the increasing availability of easy-to-use and affordable patient-oriented medical devices [1].

In this work, we argue that great benefits could be gained also by seemingly "simple" applications if these were designed to build a bridge between doctors and patients. In the following pages, we shall describe an m-health solution designed to help doctors diagnosing hypertension. We shall start providing a short introduction about the clinical problem and then we shall describe the solution adopted.

<sup>&</sup>lt;sup>1</sup> Corresponding Author: Claudio Eccher, Fondazione Bruno Kessler, Via Sommarive 18, 38123 Povo (TN), Italy; E-mail: cleccher@fbk.eu

# 1. The clinical problem

High blood pressure (BP) is a major risk factor for stroke (ischemic and haemorrhagic), myocardial infarction, heart failure, chronic renal failure, peripheral vascular disease, cognitive impairment and premature death [2,3,4,5]. Untreated hypertension is associated with a progressive increase in blood pressure, a condition often resistant to any treatment because of associated vascular and renal damage.

An accurate measurement of blood pressure is a prerequisite for appropriate management of hypertension. This is generally done through Conventional Blood Pressure Measurement (CBPM), where a doctor measures BP using mercury, aneroid or electronic sphygmomanometers. The most recent guidelines on the treatment and management of hypertension, however, have shown a sharp appreciation of Home Blood Pressure Monitoring (HBPM), with the patient checking the blood pressure at home by herself, using an automatic blood pressure machine. [5]. HBPM is able to provide BP values relating to extended periods of time, it has lower costs, it is easily repeatable and generally well accepted by the patient. For these reasons, HBPM offers a better measurement, reducing the so-called "white coat effect" or "masked hypertension" [6] and allowing a better assessment of the usual blood pressure of the patient [7]. Despite these positive features, the HBPM is not yet considered a trustworthy method to diagnose hypertension. The main hindrance is that reliable HBPM measures need to be taken following a simple but strict protocol (two consecutive measures at one minute interval; always at the same time). This process cannot be controlled by doctors, who need to rely entirely on patients. Moreover, evidence suggests that transcribing measurements from the BP meter leads to errors and that these are more frequent in people with hypertension [8].

## 2. Methods

## 2.1. The technical solution

The "hypertension diagnostic kit" (Hyper-kit) is a tool devised by Fondazione Bruno Kessler (FBK). The aim is to allow patients to manage BP measurements taken at home and to ensure doctors about the reliability of the process. It is made of an off-the-shelf NFC (Near Field Communication)-enabled electronic BP monitor and a logbook application (Hyper-Logbook) for Android-based smartphones. The patient acquires BP data from the BP meter, simply touching the device with the smartphone, thus facilitating the error-prone data entry operation.

Unlike many other systems on the market, Hyper-kit requires interaction between patients and their general practitioners. Physicians instruct patients about the correct use of the BP meter and configure the logbook, i.e., the scheduling of the measurements, which the patient cannot change. Hyper-Logbook is visually organized as a paper-based agenda, with a calendar that automatically opens on the current day. The physician can set the advanced features of the application, which are:

• The configuration of the Hyper-Logbook: for each patient the doctor can insert a new plan for BP recording, setting different parameters: the duration of the measurement period; the frequency of the measurements (e.g., two daily measurements, one every n days, etc.); the time in which the patient has to

measure BP in a typical day. As the time for the measurement approaches, an automatic notification reminds the patient to measure the pressure.

- The display of a report of BP values entered in the logbook so far, with the description of the measurement plan and the averages of the diastolic ad systolic pressure, calculated from the values entered in the indicated period;
- The synchronization of the BP data with TreC, a citizen-controlled Personal Health Record [9]. All data in the Hyper-Logbook, in fact, are stored in a local database on the smartphone. On user's request, the application can connect with the central TreC platform to upload the BP data in the PHR database. This operation, in any cases, is proposed each time the user exits from the application, to guarantee an updated central backup of the local database.

Doctors can visualize the data collected in the Hyper-Logbook by their patients and uploaded to the central TreC in a web-based dashboard accessible through a web browser, after entering their login credentials.

# 2.2. Design of the study

To test the functionality and the portability of the application in a real General Practitioner (GP) ambulatory setting, we carried out a pilot study to evaluate the acceptability of the technologies, the compliance of patients to the self-monitoring procedure and the perceived benefits and disadvantages of both doctors and patients. In the period from August to October 2013, we provided the Hyper-kit (NFC equipped BP meters and smartphones with the Hyper-Logbook preinstalled) to three GPs. The GPs recruited 15 patients, according to the following criteria:

- subjects able to use a smartphone technology;
- patients with clinical suspicion of arterial hypertension, for whom the GP needed to confirm the diagnosis; or
- subjects with known diagnosis of hypertension whose blood pressure was out of range despite the therapy.

The only exclusion criterion was the presence of arrhythmias that affect the use of automatic BP meter. Each GP was in charge of programming the configuration of the Hyper-kit, in accordance with the criteria set out in the NICE Guidelines [10], namely:

- 7 consecutive days of BP measurements;
- 2 daily measurements sessions characterized by two measurements each (at a distance of 1 minute one from the other), one in the morning and the second in the evening at regular times indicated by patients.

At the end of the cycle of measurements, we administered to patients a satisfaction questionnaire and collected the opinions of the physicians.

# 3. Results

Of the 15 patients recruited for the study, 12 accomplished the entire cycle of measurements of the BP, while three stopped early for the malfunctioning of the application, namely software errors that blocked the application, without compromising the reliability of the data collected through the BP meter. The majority of patients (13) had previously high levels of BP and were already receiving at least one antihypertensive medication, enrolled because their BP values were not targeted. All

patients returned the filled questionnaires. The majority of them were male (male/female ratio of 4:1), with age between 52 and 67 years (mean age 59), and medium - high literacy. Most of them (14) already had a smartphone and judged their computer skills sufficient or good.

All patients measured BP at home with electronic devices; in addition, four patients used ABPM; i.e., home monitoring of the BP during 24 hours through holter.

## 3.1. Patients' opinions

The majority of patients were satisfied with the Hyper-kit and did not experience any problem in completing the cycle of measurements.

Among the difficulties reported by patients there were too short shutdown time of the application at the time of data transmission, the invasiveness of the audible alarm activated by the reminder, and the rigidity of the setting time for the measurements. One patient, in particular, emphasized that during the weekend he had to follow the same rhythms as the working days, although tolerable for him.

These difficulties, however, did not affect the smooth running of the recordings. The majority of patients (14) considered this tool useful to confirm or refute the diagnosis of hypertension. Compared to the measurement mode they used before the study, patients who had previously performed ABPM preferred the Hyper-kit, since all of them considered ABPM particularly annoying during the night; in the group of 11 patients that traditionally used HBPM, however, only six preferred the Hyper-kit respect to the traditional method.

## 3.2. Doctors' opinion

All doctors agreed that the "hypertension diagnostic kit" is less invasive, compared to ABPM, since it does not require measurements at night that heavily interfere with patients' sleep. Another reported advantage of this method was that the BP values measured are not editable, since the BP meter transfers them automatically to the phone via NFC technology. With traditional registration, doctors believe that patients often tend to adjust the values according to their needs. Two GPs, finally, envisaged the opportunity to educate patients through the app. By using these tools, in fact, not only patients become familiar with the concept of long-term follow-up, but they also understand that the goal of antihypertensive therapy is to achieve a stable target BP.

### 4. Discussion and conclusions

The result of the pilot study provides some indications both for the fine-tuning of the application and for reflecting more broadly on m-health diagnostic tools.

The Hyper-kit is highly appreciated by both doctors and patients. It combines the need for reliable information and controlled data acquisition process of the doctors with the easiness of use perceived by patients, who can also smoothly accommodate the measurements' routines in their daily life. However, the experimentation revealed some open issues to address before the deployment of the system. Apart from some minor bugs fixing and some problems related to the battery duration of the smartphone, the major limit of the applications is its scarce customizability. As a patient noted, for instance, the daily routines change during the weekend but the apps does not allow

modifying the measurements timing accordingly. Another complain regarded the "intrusiveness of the remainder" and the impossibility to disable it. Finally, while the use of the kit required only a few-minutes training during the consultation, some doctors considered this extra-time hard to find when working on a tight schedule.

The study offers some food for thought about m-health applications and their potential, reflecting on some peculiarities that distinguish it from other tools available on the market. In the case analyzed here, the devices with their technical features provide the prerequisite for success. However, their setup and combination guarantee it. On the one hand, measuring devices (e.g., the BP meter) are becoming more and more user-friendly, reliable, and affordable, offering the possibility to monitor parameters outside surgeries and with no need of professional assistance. On the other hand, though, these tools can be used in many different ways while the diagnostic process requires standardized and controllable procedures. Some of these procedures can be delegated to other tools (in our case the Hyper-Logbook) to ensure their correctness and consistency. Only with this combination, it is possible to delegate safely to patients or caregivers some tasks of the diagnostic process with reliable results.

In the future, we plan to perform a cost-effectiveness analysis to compare this method with others, with particular reference to HBPM.

#### Acknowledgements

The study presented in this paper is part of TreC (Cartella Clinica del Cittadino – Citizen's Clinical Record), a broader project of research and innovation aimed at prototyping and testing a regional PHR, funded by the Autonomous Province of Trento (Italy) and managed by Fondazione Bruno Kessler.

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