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Integrated Medication Management in mHealth Applications

Hubert EBNER[a,1], Robert MODRE-OSPRIAN[a], Peter KASTNER[a] and Günter SCHREIER[a]
[a] *AIT Austrian Institute of Technology, Austria*

Abstract. Continuous medication monitoring is essential for successful management of heart failure patients. Experiences with the recently established heart failure network HerzMobil Tirol show that medication monitoring limited to heart failure specific drugs could be insufficient, in particular for general practitioners. Additionally, some patients are confused about monitoring only part of their prescribed drugs. Sometimes medication will be changed without informing the responsible physician. As part of the upcoming Austrian electronic health record system ELGA, the eMedication system will collect prescription and dispensing data of drugs and these data will be accessible to authorized healthcare professionals on an inter-institutional level. Therefore, we propose two concepts on integrated medication management in mHealth applications that integrate ELGA eMedication and closed-loop mHealth-based telemonitoring. As a next step, we will implement these concepts and analyze - in a feasibility study - usability and practicability as well as legal aspects with respect to automatic data transfer from the ELGA eMedication service.

Keywords. mHealth, eMedication, closed-loop healthcare.

1. Introduction

Continuous medication monitoring is an important component within the closed-loop healthcare cycle. Having the possibility to adjust the drug dosage contemporary to the needs of the patients allows for just in time treatment which can help to improve outcome of heart failure (HF) patients as shown within the MOBITEL trial [1]. Insufficient adherence, i.e. the degree to which patient behavior coincide with therapeutic regimen, causes worsening of the health of patients and has been identified as a serious problem in the treatment of chronically ill patients. Adherence to prescribed medication presents a challenge, in particular for elderly people and in cases where a variety of drugs have to be taken in accordance to a complex schedule. Mobile health (mHealth) applications offer new opportunities for therapy management of chronically ill patients [2]. These mHealth applications support patients in medication self-management at home.I If they are integrated in closed-loop healthcare telemonitoring solutions, they empower physicians to timely react on patient non-adherence. Adjustments of medication in a mobile app-based closed-loop healthcare monitoring program are common, in particular in HF disease management programs [3]. The management of HF is usually multi-disciplinary and comprises the cooperation

[1] Corresponding Author: hubert.ebner.fl@ait.ac.at

of several different groups of healthcare providers. A collaborative HF network called HerzMobil Tirol was recently established that combines telemedicine and nurse-led patient education and home visits embedded in a network of dedicated physicians in private practice [4]. Communication between the stakeholders of the network and relevant information of the patients (transmitted physiological data by the patients themselves as well as well-being and documented intake of HF-specific medication) are shared on the web-based TMScardio telemonitoring software (AIT Austrian Institute of Technology GmbH). This can instantly be reviewed by responsible physicians who have authorized access to the system. Experiences from this project show that monitoring of medication limited to HF-specific drugs could be insufficient, in particular for general practitioners. For an optimal treatment process knowledge about non HF-specific drugs is also required. Additionally, some patients are confused about monitoring only part of their prescribed drugs. Sometimes it happens that medication is changed undocumented without informing the stakeholders of the HF-network.

Mobile health applications on smartphones support patients in medication self-management utilizing short-range data acquisition capabilities (NFC) or the phone's camera to scan barcodes [5]. As part of the upcoming Austrian electronic health record system ELGA [6], the eMedication system will collect prescription and dispensing data of drugs of participating patients. These data will be accessible to authorized healthcare professionals on an inter-institutional level [7]. Hence, that information could be used to address automatically maintenance of the medication list. However, monitoring the intake of medication is not covered by the eMedication system. Typical short-term changes of dose or even drugs will only be documented in the telemonitoring system.

This paper shows concepts of how to integrate the eMedication service into closed-loop telemonitoring system's medication management. Therefore mHealth applications serve as interfaces. It also addresses the problem of monitoring all drugs of the medication list versus monitoring limited to specific drugs due to usability of documentation the daily intake and visualization issues on smartphones.

Thus the methods show concepts of interactions between the actors in the telemonitoring process including the eMedication. Furthermore descriptions of possible ways of accessing the eMedication and the actual documentation of mHealth applications are presented. In the results mockups of integrating the eMedication into mHealth applications as well as a visualization of the integrated medication management are discussed.

2. Methods

Adjustments of medication in closed-loop HF monitoring program will be done by the HF physician being in charge of optimizing HF therapy. The HF medication cycle is closed by documentation of medication intake by the patient (Figure 1). Medication changes made by the patient, e.g. taking a higher dose of a drug for a few days, are solely documented in the mHealth application and communicated to the backend of the telemonitoring system. Medication adjustments done by the HF-physician are documented in the telemonitoring system. In future these prescriptions will also be documented in the eMedication service. The patient can see the telemonitoring specific medication on his mHealth application. In the future the patient will be able to access his actual medication online for reading purposes using the citizen account of ELGA.

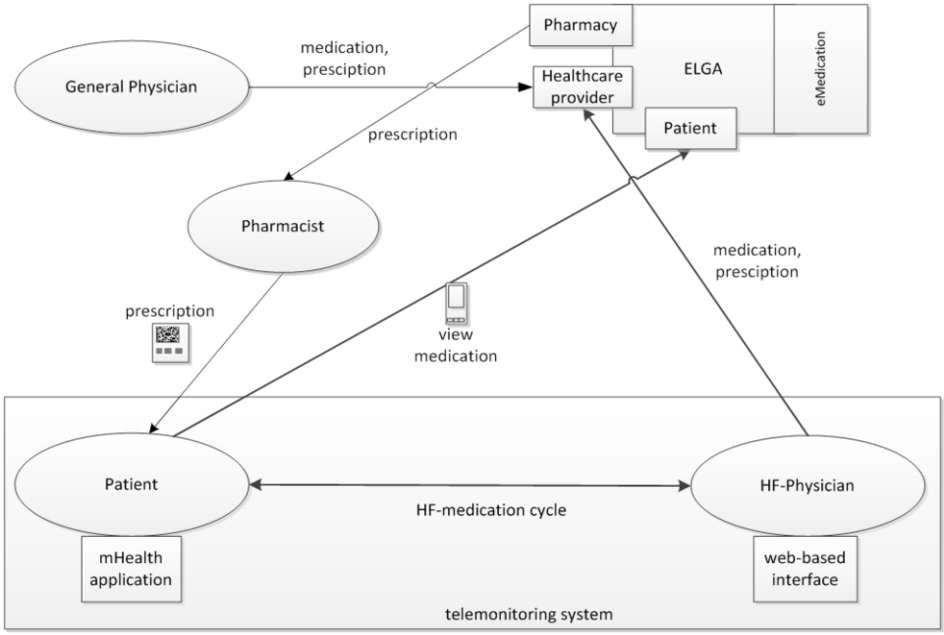

Figure 1. Concept of medication interactions between actors in the telemonitoring process including ELGA

Additionally, prescriptions might be given by other healthcare providers (e.g., general physicians) and the patient can get prescription and the drugs from the pharmacists (Figure 1). The pharmacist will fetch a new prescription from the eMedication service and deliver a hard copy of the prescription including a unique eMED-ID to the patient.

As can be seen in Figure 1, the patient can get information about the medication from three different sources: from the eMedication service via the citizen account, from the pharmacist via the prescription and from the mHealth application of the telemonitoring system. The remaining section of the methods describes possibilities to gain access to the ELGA eMedication service via citizen account and data matrix on printed prescriptions as well as the documentation process in the mHealth application of the telemonitoring system.

2.1. Accessing ELGA eMedication service

ELGA offers variable possibilities to gain access to its system. The focus in this paper is thereby put on the authentication with a citizen account [8] and the eMED-ID [9] on printed prescriptions.

2.1.1. Citizen account

Patients have the possibility to check their ELGA data via web interface. Therefore, a special authentication is required. One possibility is using the cell phone number, a signature password and a mobile TAN (mTAN). A prerequisite for this process is a "Handy-Signatur" that has to be activated beforehand [10]. After the authentication the citizen is allowed to view his electronic health record including the eMedication data. The basic idea is to integrate this authentication method directly into the mHealth application for logging into the eMedication service.

eMED13 15e5x8
p45qw1 235aab

John Doe | Dr. House | PLAVIX 75 | 1/1/0/0 | clopidogrel | PLAVIX| fim-coated tablet | 75 mg | oral | twice per day

Figure 2. Sample eMED-ID (left) and sample data matrix for one drug (right)

2.1.2. Data matrix on printed prescriptions

Hard copy prescriptions generated by ELGA may contain an eMED-ID. It would allow authorized stakeholders like pharmacists to access the electronic counterpart in the eMedication without any further authentication. The eMED-ID is presented as a number and a data matrix (Figure 2, left), similar to QR-codes. Data matrices can be scanned easily by reading devices or smartphones with integrated cameras. For this purpose, a special software module is integrated in the mHealth application to provide a scan function by using the integrated camera, to take over the task of authorizing the smartphone in the eMedication and also to govern the exchange of information between them. Each prescription has its own eMED-ID. Thus, the eMED-ID authentication method is limited to the prescription the eMED-ID belongs to.

In Germany, there are similar considerations concerning electronic medication plans [11]. Printed medication plans contain a data matrix (Figure 2, right). In contrast to the ELGA generated data matrix that contains only the eMED-ID, the entire information of the medication plan is stored in the German data matrix. Generally, the medication plan contains data about the patient, the physician and each drug with description, dose and signature. For this reason there would no interaction with an eMedication service be required.

2.2. Documentation in the mHealth application

Currently, there are two kinds of patient's documentation used in mHealth applications. The first kind applied in a telemonitoring project implemented at the Krankenhaus der Elisabethinen Linz, Austria [12] uses a combination of TAGboards and smartphones with integrated NFC interfaces. These TAGboards consist of programmed NFC tags [13]. Each NFC tag is indicated with defined symbols and words for the documentation of the medication. By touching a tag on the TAGboard with the NFC interface of the smartphone the patient documents his actual medication intake. The second kind of documentation used at the HerzMobil Tirol project [4] builds on the touch screen technology of smartphones. The symbols and words for documentation are displayed on the smartphone's screen and can be selected by the patients directly by touching them.

3. Results

The mHealth application on the smartphone serves as patient terminal to the HF disease management program. In order to combine eMedication service and closed-loop telemonitoring towards integrated medication management, the mHealth application

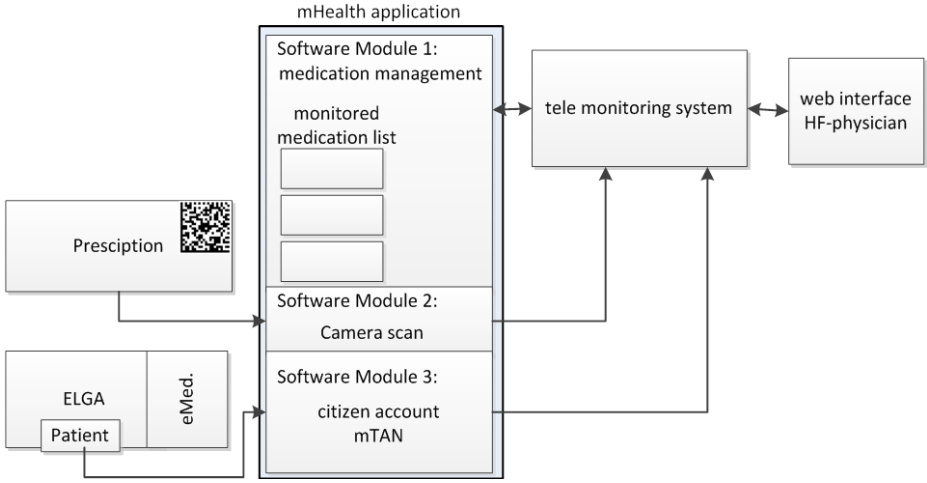

Figure 3. Medication update on a mobile application

should support the workflow of updating the monitored medication list. Figure 3 presents a workflow that incorporates the ELGA citizen account and a data matrix on prescriptions. The mHealth application contains three different software modules: medication management and visualization (software module 1), actual prescription (software module 2), and medication changes (software module 3).

Software module 1 contains the actual medication management including the visualization of the monitored medication. Software module 2 is responsible for the actual prescription using the onboard camera to scan the data matrix. Whenever a new medication is prescribed the patient scans the eMED-ID of his hard copy with his smartphone. The mHealth application identifies the eMED-ID, fetches the correct prescription from the eMedication and sends it to the telemonitoring system. No medication changes regarding the patient's monitored medication list are made in the mHealth application yet. The HF-physician checks the medication changes and prescriptions to decide which new drugs have to be added to the monitoring and which have to be dropped. Following this, the new drugs are transferred by the telemonitoring system to the mHealth application and added to the monitored medication list. Software module 3 implements the citizen account in the mobile application. The mHealth application connects to the eMedication service and checks for medication changes and descriptions of drugs. After that the new information is sent to the telemonitoring system. Again the prescription is checked by the HF-physician and feed back to the mHealth application. While module 2 is executed on demand, i.e. the patient gets a new prescription, module 3 has to be launched periodically (e.g. once a day) to ensure a complete medication update in the telemonitoring system. Figure 4 shows a mockup of the medication management (software module 1) in the mHealth application. The medication intake is presented as a list (Figure 4, left) or a single view (Figure 4, middle). The patient has four choices to document the medication intake: exact, more, less, or none. The list view is segmented into pages containing preselected choices once done by the patient. These choices are visualized as green hooks, red crosses, and blue arrows (up and down). Additionally, short names for each drug and below the daily signature are visualized. The list was introduced to simplify the documentation for up to ten and more drugs, especially if the documentation stays almost the same each day. The patient is able to quickly check the medication list with a minimal amount of taps.

Figure 4. Mockup mobile device medication

Touching a list element leads the patient to a more detailed single view of a drug with additional information containing again the short name, the signature, a picture of the actual drug and the selection menu with the possibility to change the preselected choice of the drug intake (Figure 4, middle). An additional implemented feature is that touching the picture of the drug shows detailed information about pharmaceutical ingredients (Figure 4, right).

4. Discussion

The integration of the ELGA eMedication service and telemonitoring services will achieve an important improvement towards integrated medication management in telemonitoring programs. The entire medication information of a patient is available. Medication changes outside the telemonitoring program are considered. The same applies to short-term changes of dose or drugs in the telemonitoring system. Additionally, no non-HF-specific medication is left beyond.

Finding a suitable solution of displaying the medication plan on smartphones is a very important point for supporting documentation of medication intake. The quite small display on smartphones in combination with the amount of monitored drugs may lead to some issues of the visualization of the required information for the patient. The single medication view (Figure 4, middle) offers the necessary information. However for more than five monitored drugs it gets tedious to note each drug individually, particularly if the documentation does not change over days. The medication list view (Figure 4, left) enables the patient to quickly check the monitored drugs and finish the documentation with a minimal amount of taps. The disadvantage may be that patients blindly accept the preselected drug notes list without verifying them. Changes in the intake could just be ignored by the patients. In order to counteract this behavior the patients should be forced to periodically (e.g. once a week) check all monitored drugs separately by forcing the single medication view.

The concept of using a data matrix on a printed medication plan particular the German approach would be a feasible way of getting the actual medication without

implementing interfaces between ELGA and telemonitoring services. It is still important for patients to hold something in their hand to look at the printed prescription and patients get used to the scan functionality of smartphones quite fast [5]. Using the citizen account authentication to access the eMedication service and to fetch medication data is very promising but there are some hurdles to be taken as well. The usability may suffer as it may not be easy and intuitive for every patient. Especially elderly patients and those who are less experienced with smartphones could run into problems by first getting the smartphone ready with the "Handy-Signatur" and second logging into the eMedication with the mTAN authentication. As the mHealth application is connected to the backend of the telemonitoring service, it might be possible that this service will handle the mTAN authentication automatically. Further investigations will show whether that approach could be visible with respect to data security, privacy and usability.

Continuous medication monitoring is essential for successful closed-loop healthcare, in particular for the management of chronic diseases like heart failure. Hence, it is important to provide the actual and total medication on the mHealth application. The proposed concepts illustrate ways to integrated medication management in mHealth applications.

As a next step, we will implement these concepts in TMScardio telemonitoring software. The implementation will be followed by analyzes - in a feasibility study – of usability and practicability. These will be carried out under consideration of legal aspects to automatic data transfer from the ELGA eMedication service.

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