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Supporting Blind and Visually Impaired Persons in Managing Their Medication

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Abstract. Various reasons lead to non-adherence to drug therapy, such as forgotten reordering of medications or wrong intake behavior. Blind and visually impaired persons face additional challenges, such as recognizing the medication package or reading the package insert which additionally impacts on patient safety. To address these challenges, we developed a concept for supporting medication management. In the center of the concept is the mobile application MyPills. It reminds on drug intake and reordering. These functionalities are made available to blind and visually impaired persons using screen reader functionalities. The current medication is entered into MyPills using the eMediplan, a Swiss national exchange format for eMedication. Beyond, package inserts are made accessible through voice output. MyPills supports in scanning the global trade item number (GTIN) for medication package identification. A usability tests carried out with six participants including two blind persons showed that users get along well with the app and the functionalities are helpful. In future studies with patients, it should be checked whether the MyPills app can improve compliance with drug therapy and impacts on intake behavior.

Keywords. Medication management, mHealth, accessibility, medication adherence, mobile apps

1. Introduction

Several issues impact on patient safety and outcomes of drug treatments: overdosing, drug interactions, contraindications, or non-adherence (taking an incorrect dose, taking medication at the wrong time, or increasing or decreasing the frequency of doses without interacting with the prescribing physician) [1,2]. Reasons for non-adherence often include patients' forgetfulness, inadequate knowledge, or lack of understanding of the consequences of poor compliance.

There is a growing number of smartphone apps available to help people managing their medication [3]. Delivering self-management support digitally, including support for understanding and managing treatment, has shown improvements in health outcomes and processes of care for patients with chronic conditions [4]. However, most of the currently available apps only provide intake reminder functions, i.e. they follow a behavioral adherence strategy [5]. Re-fill reminder are rare and also medication

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management apps that are accessible for blind and visually impaired persons are still missing. We could not identify such an app when searching in App stores.

Therefore, we are focusing in this paper on the research question, how a mobile application can support blind and visually impaired persons in managing their medication or more specifically, which technologies and functionalities should be provided to facilitate medication management for this particular user group. We introduce a corresponding concept and implement it in the mobile application MyPills.

2. Material and Methods

2.1. Concept development

In order to develop the concept for supporting the blind and visually impaired, an analysis was carried out, which consisted of three phases: First, the challenges in drug management for this particular user group were identified. We searched for literature in scientific databases (Pubmed, IEEE Xplore Digital Library, ACM Digital Library and Google Scholar). Further, we conducted an interview with the head of the Technology and Innovation Unit of the Swiss Federation of the Blind and Visually Impaired, with three pharmacists and one physician specialized in ophthalmology to collect existing challenges and problems with respect to medication management for patients. Beyond, we examined in a second phase the possibilities and recommendations described in the literature to help blind and visually impaired people managing their medication. In particular, guidelines from the American Foundation for the Blind for creating drug and medication management information suitable for blind and visually impaired were considered [6].

Phase 1 and 2 resulted in challenges of blind and visually impaired in medication management. In a third phase, for each of these challenges three different variants of solutions were developed. We evaluated these variants according to feasibility and time factor. Finally, we used the best solution for each challenge to build our concept for medication management.

2.2. App development

Based on the concept developed to support blind and visually impaired people in their drug management, the requirements of the MyPills app were defined. The MyPills app was developed using Ionic (https://ionicframework.com). Ionic is a cross-platform mobile development technology. It allows to build applications for mobile devices and desktop computers using web technologies. Accessibility guidelines from W3C (https://www.w3.org/Translations/WCAG20-de/), iOS and Android were considered in app development [7,8].

2.3. Usability test

In order to assess the usability of the MyPills app, usability tests with two blind persons and four normal sighted persons (age between 30 and 70) were carried out. Normal sighted persons were involved since the application is expected to be useful for this user group as well. We recruited them from our personal context. For recruiting blind

persons, we contacted the Swiss Federation of the Blind and Visually Impaired. Unfortunately, only two persons were willing to join the test; people were either afraid or not interested in testing the application. We defined five scenarios that had to be addressed by the subjects using the app: 1) Test the application and find out about its functionalities, 2) Find out which medications you should take today at 6 pm, 3) Find out which medications have to be re-ordered, 4) You feel dizzy and have headaches; check whether these symptoms can be due to the intake of the medication Dafalgan (agent Paracetamol), and 5) You have two packages and want to find out which one is Dafalgan. The fifth scenario was only tested with blind persons.

The test persons received a smartphone with the pre-installed app from the test leaders. The initialization was carried out by the test leaders since our concept foresees later the support of the service provider in app initialization. The scenarios were read out by the test leaders. The test persons were not allowed to ask any questions and had to carry out the tasks independently without help. Unstructured interviews were conducted by two of the authors before and after the test. Pre-interviews collected information on the individual app usage. Post-interviews collected feedback on the usage experience and recommendations for improvement, including:

- How do you like the structure of the MyPills App?
- What do you particularly like or dislike in the app?
- What was unclear to you?
- Was the initialization process to get started with the MyPill App intuitive?
- What benefits does the MyPills App offers to you?
- What can be optimized? What is missing? What should be omitted?
- Would you integrate the app into your everyday life?
- Would you reorder your medication via the MyPills App?

Further, the interaction with the app was monitored, but no help was given. The results were recorded in a Rainbow Spreadsheet.

3. Results

3.1. Results from literature search and interviews

The literature review revealed that blind and visually impaired persons are confronted with additional challenges with respect to their medication management. These comprise correct dosing of medications, in particular of liquids, recognizing medications or distinguishing different packages and their shapes, reading and understanding package inserts with medication information or dosage instructions, recognizing expiration date, correct medication intake [9-11]. Furthermore, medication packages are often not equipped with descriptions in Braille, people cannot read Braille or other labels cover the Braille description [9-11]. Even though EU regulations (e.g. Directive 2001/83/EC, supplemented by 2004/27/EC) exist that make it mandatory to print the drug name in Braille on the package, these regulations are neither entirely implemented nor consistently monitored. Furthermore, it is impossible to place Braille on small packages and also difficult to ensure the readability [12]. One of the interview partners formulated an additional problem: The package insert is currently unavailable for blind persons. From these results, we derived four challenges to be addressed by our concept (Table 1).

3.2. Solution variants for the identified challenges

Table 1 shows for each of the four challenges the solution variants that we developed. The highlighted solutions were selected for our concept.

Table 1: Variants for challenges. 1 = low effort, 2 = medium effort, 3 = high effort

Variant	Feasibility	Time factor	∑
Challenge 1: Recognizing drugs and dosage information			
Label with dosage information in Braille or a font size legible for the blind or visually impaired	3	2	5
Label with simple marking, which is attached next to the GTIN and serves to locate the GTIN, so that it can be scanned with a smartphone application. No label with dosage information on the medication package.	1	1	2
Attaching other markings that allow distinguishing drug packages.	1	1	2
Challenge 2: Accessing package insert or intake instruction			
Package insert in Braille or a font size legible for the blind or visually impaired	3	2	5
Linking a website with patient information on drugs	1	2	3
Smartphone application that provides direct access to patient information	1	1	2
Challenge 3: Recognizing expiry date			
Expiry date in Braille or a font size legible for the blind or visually impaired	3	1	4
Smartphone application that reminds on expiry date	2	1	3
Reminding phone calls or SMS by health professionals or the healthcare team	3	3	6
Challenge 4: Reminder for drug intake			
Dosage boxes with integrated alarm functionality	2	2	4
Smartphone application with reminder	1	1	2
Reminding phone calls or SMS by health professionals or the healthcare team	3	3	6

3.3. Concept

Our concept comprises three levels involving pharmaceutical companies, health professionals, and blind or visually impaired persons (Fig. 1). The MyPills app helps in identifying medication packages and provides information on a medication. For this purpose, a health professional places a marking next to the GTIN on the medication package, so that a blind or visually impaired person is made aware of the GTIN's location which can then be scanned by the MyPills app. The initial set up of the app,

i.e. scanning the QR code of the eMediplan to add the prescribed medication as background knowledge to the app, is also done by the health professional, for example by the pharmacist. Once this is done, the patient interacts with the app, receives reminder and information on the medication. The functionalities are described in more detail in the following.

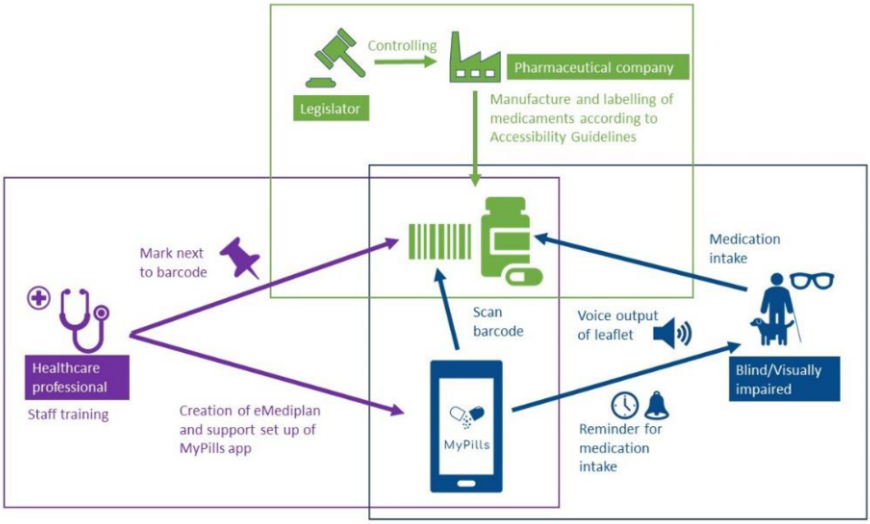

Figure 1. Concept underlying the MyPills app. In principle, legislation should monitor that accessibility guidelines are implemented in medication packages and that they are equipped with Braille. To bridge the gap, we suggest that health professionals put a marking on the drug package to indicate the location of the GTIN. All relevant medication information, dosage, intake and refill reminder will be provided by the MyPills app.

3.4. MyPills app

The MyPills app helps the blind or visually impaired in medication management. In particular, the following functionalities are provided:

- Identification of medication package by scanning the GTIN on the medication package
- Voice output of medication name and intake schema
- Voice output of the package leaflet

The MyPills app offers additional functionalities to help not only blind or visually impaired, but also normal sighted people to manage their medication. The QR code on the eMediplan, the Swiss national exchange format for eMedication, can be scanned. The corresponding medication and dosage information is automatically stored in the MyPills app. The QR code of the eMediplan can in turn be displayed which helps to transfer the current medication to another health professional. For long term prescriptions, the validity is stored and MyPills reminds when a renewal should be initiated. This allows the re-ordering of medications using the app.

Medications to be taken on a current day are shown as prescribed and recorded in the eMediplan and corresponding intake reminders are provided by MyPills. Standard and even complex dosages are shown. Complex dosages include intake behavior when

stopping a drug – in these cases, the dosage has often to be reduced continuously. MyPills supports in this process. Other complex dosages include cyclic intake (e.g. take drug for 2 weeks, then stop for 2 weeks and continue afterwards). Even these intake schemas can be covered by the app, sending corresponding reminders.

Based on the package size, the reserve on a particular drug is calculated and re-ordering notifications are sent to the patient to avoid that he or she runs out of medications. The order can be released through the app when a specific pharmacy has been specified. The package insert can be accessed by a link to the Compendium (compendium.ch), a database that contains all drugs that are approved in Switzerland with corresponding information on contraindications etc.. Through screen reader functionalities, the package insert, intake schema or drug name can be read aloud. A health professional can be specified in the app to be contacted by E-Mail or telephone.

4. Discussion and conclusions

Three broad categories of adherence strategies, *affective* (targets adherence through appeals to feelings and emotions or social relationships), *behavioral* (targets adherence by targeting, shaping or reinforcing specific behavior patterns), and *educational* (targets adherence by conveying information) can be distinguished [3]. Park et al. [13] found out that the majority of medication adherence apps have features representing a behavioral approach to intervention. MyPills has the following features: tracking medication taking (behavioral); reminding to refill and indicating amount of medication left (behavioral); storing medication information (educational); providing complex medication instructions or notes; database of medications (educational).

4.1. Usability test results and research question

The test results showed that the test persons immediately understood the MyPills App and its functionalities and considered app and concept very useful. The app was perceived as clear and understandable. The blind people found the scanning of the drug package very helpful and would prefer if the camera has a larger scatter so that scanning is facilitated. All test persons would use the MyPills App in everyday life. They considered the online link to the package insert and the voice output of the package insert very helpful. Overall, the concept for supporting the blind and visually impaired with the MyPills app is a viable way to support the medication management of the blind and visually impaired. Nevertheless, it should be mentioned that only two blind test subjects could be recruited for the usability tests. Further usability tests have to be carried out to ensure the usability of the application.

The main research question in this work was how a mobile application can support blind and visually impaired persons in managing their medication. The MyPills app helps the blind or visually impaired to identify the medication by reading the GTIN on the medication package and reading the medication name and other information about the medication. We found out that screen reader functionalities can be used to provide access to the package insert and help in interacting with the app. In future, information retrieval functionalities could be integrated to allow specific questions instead of reading the entire package insert at once (e.g. the question “what are the contraindications?” could be posed and the corresponding paragraph will be read aloud).

Stawarz et al. suggest that also complex intake schemas should be supported by medication management applications [14]. In MyPills, we specifically integrated complex dosages and intake schemas. In summary, the MyPills app provides functionalities to reduce the risk of incorrect intake. In future studies with patients, it has to be checked whether the MyPills app can actually improve adherence and compliance with therapy and how it impacts on medication safety.

4.2. Accessibility

Switzerland has set up an eCH specialist group "Accessibility" and developed the "eCH Standard 0059". These instruments are intended to make the necessary information and services available to public authorities and other providers. In this way, the services offered on the Internet can be implemented according to uniform criteria. A practice-oriented checklist has been made available so that the technical implementation and review of the WCAG-2.0 requirements and eCH standard can be reviewed. These documents are publicly available on the www.ch.ch/accessibility website. We tested the MyPills App with the checklist. In summary, it can be said that the MyPills App has fully met compliance categories A and AA and is therefore a barrier-free app.

4.3. Practical implications

Our concept foresees to integrate a health professional into the process of app installation or marking of drug packages. In order to keep the effort as low as possible, the approach was chosen that only a simple marking, not related to a specific medication, is attached to the drug package next to the GTIN, so that the blind or visually impaired person is made aware of the localization of the GTIN. The usability tests have shown that it was easy to recognize the marking, but the blind and visually impaired prefer a mark that also indicates the direction in which the barcode is located, such as an arrow symbol. We have used simple round markers for our usability tests. As a result, the blind were unsure whether the GTIN was to the right or left of the marking. Another option would be to have 2 markings indicating two borders of the GTIN. Furthermore, the test revealed that the MyPills app must provide more precise information about the distance between the smartphone and the medicine package in order to enable optimal and rapid scanning of the GTIN.

We asked in our interviews how much time health professionals could invest in the explanation of the app and marking of drug packages. The pharmacist and the physician claimed that 10-15 minutes per patient would be realistic. Thus, our concept could be well realized in practice. However, it is recommendable that all medication packages are enriched with accessible information right from the production to help the blind and visually impaired recognizing the package. In addition, the inscription of the medication should be made in the font size specified in accessibility guidelines [6,15] and color blindness should also be taken into account when selecting colors for designing dosage instructions [9]. How many drugs in Switzerland actually bear Braille and whether the pharmaceutical companies comply with the accessibility guidelines was not examined in detail in the context of this work. Since 2019, drug packages are equipped with a 2D data matrix for more security and safety against forgery. Wesch suggests to store additional information in these data matrixes [12] and to use mobile applications to retrieve this information [12]. The information could be even made

available in different languages. The MyPills app could be well used to read the data matrix information.

The reordering functionality has already been implemented. Of course, it is only possible to reorder medications where a long term prescription is available. The app stores the validity of the prescriptions and also reminds when the validity ends. A pharmacy has to implement a digital reordering process to make use of this functionality. The concept has to be evaluated in cooperation with health professionals in pharmacies and doctors' practices in order to clarify its implementation in practice more precisely.

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