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Towards a Critical Perspective on mHealth Applications

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Towards a critical perspective on mHealth applications

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***Abstract*—Today's world is influenced by technologies which create opportunities to support people in their daily lives. Companies promote and market products in different ways to reach everybody and to maximize their turnover which is especially relevant for the healthcare sector. People with diseases could find relief by dealing with the illness, but the provided applications and information come with a huge responsibility for patients. How far can these applications support people without risks and what about the usability of medical treatments and diagnosis? This paper is primarily concerned with these questions and correlates the current problems in the development process of mHealth applications.**

I. Introduction

Many people in the world do not have access to adequate medical treatment, and are looking for solutions to get full coverage. On the other hand, there are people who need support with their medication, nutrition, and many have chronic diseases like hypertension, diabetes mellitus or asthma.

It is not easy to find a solution which is comfortable, easy to understand and financially accessible. However, there is a new idea to help people with these above mentioned problems.

In 2016 over 4.6 billion people own a mobile phone or a smartphone [1]. It would be great to not only use these phones for messaging and calling other people. This leads to the concept called mHealth which is a technology that creates more opportunities for people to get additional support in their daily lives. It is an abbrevation for mobile health and a generic term for the medical support by mobile devices like smartphones, personal digital assistance or tablets for example [2], [3]. There are a lot of useful applications collecting and analyzing personal data for insight and wellness. Also, it is very interesting and useful for physicians and patients to find a better medical treatment. *But how meaningful are these data and is it possible to use them for medical treatments and diagnosis?* These are two of the main points which are elaborated in this paper.

The following chapter acknowledges the requirements for these kinds of systems. The current state of the art system is shown, and quality aspects and limitations of mHealth software will be discussed. After that, some solutions will be given, and finally there will be a look at future opportunities of mHealth.

II. Requirements

A. Diabetes mellitus

In the previous section there are some examples of chronic diseases but certainly many more exist. Take a closer look at diabetes mellitus for example which has grave social and economic implications for individuals and society. It is a prevalent chronic disease and in 2015 about 415 million people worldwide were affected [4].

In most cases, for over 60% of people, it is possible to avoid the disease fully or delay the progress of it with sport and an appropriate diet [5]. The support in this area by mHealth is shown in a later Prevent chronic disaeses subsection.

Diabetes can be fatal, and primarily, there are two kinds of diabetes called type 1 and type 2 [6]. Patients have personalized treatments, and need support with their daily medication routine especially with insulin. This also includes measuring blood sugar levels often through out the day. Therefore, a support system needs to be versatile and self explanatory and consequently usable for all generations. The most important point is the reliability in all situations.

B. Rehabilitation

Worldwide, in 2014 more than 1.9 billion adults were overweight and out of those over 600 million were obese [7]. Normally, people get an active therapy care plan with exercise, diet plans and instructions [8]. Furthermore, they need support by tracking important data, such as vital signs and consumed and burned calories [9].

Also, patients do not have long stays in rehabilitation centers or hospitals, instead they have the opportunity to remain in their familiar environment. This could help improve their healing process. The mobile devices should collect data like blood pressure allowing the physicians to make better treatments and diagnosis. It could also improve the communication between patients and medical doctors.

As shown above there are a lot of requirements which are important for patients and it is difficult to provide all the specifications with high quality standards.

III. State of the art

As mentioned earlier there is a large variety of mobile applications which are designed to improve livability. In the app stores, there were over 165,000 healthcare applications in 2015 [10]. Out of these, almost 140.000 applications are

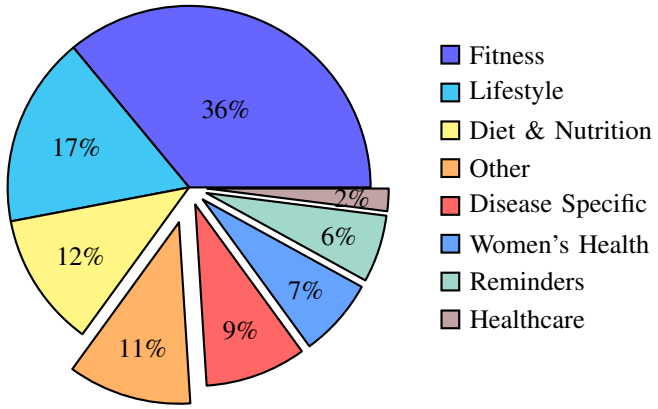

Figure 1. Distribution of mobile applications in the iOS/Google app store in 2015 (Adapted from [10])

listed in the two major app stores, Apple App and Google Play Store, and new ones become available daily. Worldwide, in 2015 over three billion downloads of healthcare applications were estimated. The year before there were 2.3 billion and in 2013 1.7 billion downloads. [11]

The mobile applications are classified into the following distributions, shown in the pie chart above. Much more than 50% of the applications belong to the wellness sector, which include Fitness, Liftestyle, and the Diet and Nutrition areas. Less than 25% are available in disease and treatment management. [10]

A. Prevent chronic disaeses

Chronic disaeses can be caused by the lack of physical activities, unhealthy food, or stress [12]. Good examples are overweight or obesity which encourage the onset of diabetes [5]. This leads to the wellness sector of the pie chart which is subdivided into three parts. The area of Diet and Nutrition has an amount just under 15%, Fitness less than 40% and Lifestyle short of 20 % respectively [10]. In these categories there are many mobile applications which can help people to eat clean and encourage users to do sports.

People with diabetes in the early stage have a good chance to rid the disaese with sports and an appropriate nutrition [5]. At this point there are applications which allow the user to track their food, and also calculate their personal consumption of kilocalories distributed, proteins, carbohydrates and fats called macros. As an example, the most current downloaded food tracking application has been MyFitnessPal [13] in April, 2016. According to their website there is a huge database behind the system which includes more than five million food data items including calorie count, fats, carbohydrates and protein values [13]. The software provides an interface enabling users to enter their food data items. Subsequently, they get the kilocalories and macros displayed. Those concerned can adjust their nutrition and have the opportunity to create meal plans.

Sports, shown in the pie chart as Fitness, supplies many possibilities for users inculding full cardio workouts, weightlifting and mobility training. Instructions, tutorials and descriptions are available and furthermore, it is possible to document the progress of each exercise day after day. As a result there will be a saved history of the users progression, giving physicians the opportunity to get a more detailed look into patients life. Doctors can analyze daily nutrition and sports routines enabling them to optimize medical treatments and diagnosis.

B. Supporting diabetes mellitus patients

Mobile applications, especially for the usage by diabetics, are included in the disease specific area of the pie chart. As mentioned in the Prevent chronic disaeses subsection, applications e.g. food tracker are also usable for diabetes patients.

Furthermore, they would need applications providing functions such as an automatic blood glucose tracker. To eliminate errors caused by users, they can connect the smartphone with the blood sugar monitoring device and it downloads the blood glucose readings to the smartphone [14].

A further requirement particularly for type 1 patients and diagnosis is the glycosylated hemoglobin or short A1C monitoring [15]. It is a form of hemoglobin indicating the status of diabetes millitus which is used to identify the three month average plasma glucose concentration which benefits a better diagnose [16].

It it possible to use these mobile applications to collect data allowing the physicians to get an overview of the patient's. Blood glucose, A1C, heart rate, blood pressure, nutrition and many more values are gathered over a long period [17]. Thus, the therapies become more individual. Additionally, applications can provide remote diagnosis and chronic care from anywhere by transmitting collected data from mobile devices to physicians. They do not have to be in the vicinity of patients to monitor their health values.

C. Obesity focused rehabilitation

MHealth applications provide particular tools for monitoring vital signs, collect reliable measurements and the effects of home exercise programs. Futhermore, it supplies educational material for patients. [18]

In the case of people with obesity two technical components need to be considered for mHealth-based rehabilitation applications in order to facilitate weight-loss.

Self-monitoring allows users to record the progress of food intake and physical activity [19]. As mentioned earlier, there is still a large group of food tracking applications available.

Personal feedback and recommendations from a counselor can encourage, assist and motivate patients to reach results [19]. Therefore, the applications send data from patients to the patient-centers or physicians ensure the best medical treatment or diagnose. It can occur in different ways. The simplest which is provided by mHealth is SMS/MMS, but in the century of internet there are some other possibilities. One would be transmitting the collected data directly to a server to exclude personal mistakes, therefore they are always available in the most updated version.

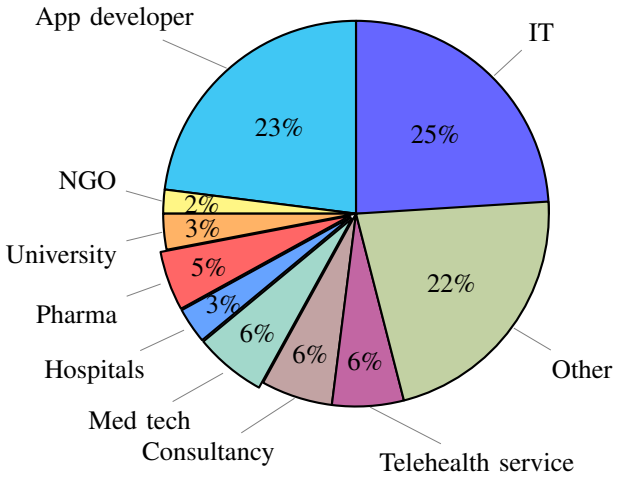

Figure 2. Average distribution of app developer teams in 2015 (Adapted from [11])

IV. Quality & limits

A. Who is behind the applications ?

As seen in the pie chart above there are many mobile applications in the wellness management area. A reason is that the app developers do not need a large medical backround to write these applications. All in all, the majority of app publishers are not experts. [11]

The chart above shows the involvement of pharmaceuticals, hospitals and med tech companies with 5%, 3% and 6% in the mHealth application market respectively. That is very critical because patients have to trust these applications but less than 15% of the developers have a medical backround. In the following subsections the questionability of mobile applications combined with chronic diseases will be discussed.

B. Data analysis

Food tracking applications attract customers with a huge amount of food data items in their databases. By putting the name of the groceries into the system it shows the sustenance. Anybody is able to insert food data items with nutritional values into the databases, therefore redundancy is unavoidable. A selection from MyFitnessPal's database provides the results shown in Table I. Banana for example is around 3200 times in their database. Of course there are various kinds of bananas, but frequently the exact same one is added with different values in the database. This problem is called data inconsistency [20].

Table I
Experiment on the food tracking application MyFitnessPal

Input	*Search results*
Rice	`2832 times in the database`
Pasta	`1828 times in the database`
Bread	`>10000 times in the database`
Banana	`3236 times in the database`

Diabetes mellitus patients especially need absolutly reliable food values. In particular the carbohydrate values are very important because of the proportion to insulin [21].

Applications attempt to calculate personal consumption of kilocalories, but they cannot consider people with pre existing diseases in their computation.

> "To define the basal metabolism which is the minimal rate of energy expenditure per unit time by endothermic animals at rest" [22]

existing four general formulae with two for each gender [23].

i) $Gm(m,l,t) = (66,5{+}13,7\frac{1}{kg}m{+}5,0\frac{1}{cm}l{-}6,8\frac{1}{a}t)\frac{kcal}{24h}$

ii) $Gw(m,l,t) = (665+9,6\frac{1}{kg}m+1,8\frac{1}{cm}l-4,7\frac{1}{a}t)\frac{kcal}{24h}$

iii) $G_km(m,l,t) = (3,4\frac{1}{kg}m{+}15,3\frac{1}{cm}l{-}6,8\frac{1}{a}t{-}961)\frac{kcal}{24h}$

iv) $G_kw(m,l,t) = (2,4\frac{1}{kg}m+9,0\frac{1}{cm}l-4,7\frac{1}{a}t-65)\frac{kcal}{24h}$

The Harris-Benedict-formulae i) and ii) with the parameters weight(m), size(l) and age(t) are for men (Gm) and woman (Gw) with a Body-Mass-Index (BMI) under $30\frac{kg}{m^2}$. For people with a BMI over $30\frac{kg}{m^2}$ there are other formulae because of a lower basal metabolism caused by higher body fat [24]. G_km and G_kw are corrected with the Broca-Index calculating the personal consumption of these persons. [23]

Diseased people do not belong to these categories. Obesity can be caused by metabolic diseases, hypothyroidism or diabetes for example [12]. The thyroid 's main job is to produce T3 and T4 hormones. It regulates the body's metabolism and slows down many of the body's functions when it does not produce enough of these hormones. [25]. Thus, the basal metabolism is even lower. Conclusively, the computed values are not meaningful for patients. They are only "guidelines" for non-diseased people.

C. Workout evaluation

As mentioned in the previous IV-A section less than 15% of the developers have a medical backround [11]. This leads to unprofessionalized and unpersonalized workout or training plans. If people have a pre-existing disease, for example a disc prolapse, it is not considered in these applications. All people are individual and have different needs. This fact is not involved in the development process of mHealth applications. The current mobile applications are non-applicable for diseased people. Furthermore, there is no observation control by professionals as in rehabilitation centers. Up until now a mobile application cannot control the proper execution of an exercise. Therefore, e.g. physiotherapists are still needed for medical treatments.

D. Limitations

1) Additional costs: Using the example of diabetes and obesity, most of the "premium" applications are not complimentary and often ancillary equipment is needed. Whether it is the blood sugar monitoring device or the sensor wristband for a 24/7 monitoring, it all creates some costs. Often, people cannot use their "old" devices because of the equipment compatibility. That is against the idea of mHealth which uses an existing technology to make someones life easier and better.

2) The inconvenience: Another problem is the integration into a patients everyday life. As reviewed in Data analysis section food tracking applications are *inconsistent*, therefore patients have to take a detailed look at the provided information. Futhermore, they have the problem of *redundant* data, which could be frustrating and annoying for them. Also in the case of children a huge potential for serious misentries exists.

3) The overestimation: MHealth software have some risks for laypeople that may think mobile applications can replace professionals. As seen from the previous Data analysis and Workout evaluation sections, applications have some quality problems and they are not suitable for everyone, particulary people with diseases who do not know anything about their ailment. As an example a food tracking application cannot compute basal metabolim for people with hypothyroidism. These patients should see physicians who have professional knowledge and medical equipment to make a diagnose.

4) Data privacy and security: The transparency of applications is often missing. By looking at current App Stores in May, 2016, it does not matter if it is a free application or not, most providers have no information about the privacy policies in their app descriptions or websites. Even privacy organisations have published several reports with the same perception [26]. According to the Oxford Journal, only 30.5% of the applications have privacy policies [27]. Since Snowden's revelations about the abuse of personal data in the United States of America more attention has been paid to this topic. Simultaneously the extent of sensitive data and no information about their usage makes these application a security risk [28].

V. Solutions

1) Closer cooperation: Developers and physicians should work hand in hand on a project, so applications could accomplish higher quality standards. The disease and treatment management area, shown in Figure I have less problems in this area than the wellness management area. It is owed to the knowledge that people need to develop such an application as mentioned in Workout evaluation section.

2) Valuation system: The Institute of Health and Biomedical Innovation (IHBI) has in cooperation with others done research towards rating mobile applications. Actually there is no app quality assessment tool beyond *star-ratings* or *user evaluations*. Both are indicators for reliable applications but the IHBI is looking for a reliable, multidimensional measure for trialling, classifying, and rating the quality of mobile health applications solution [29]. The result found that the Mathematics Anxiety Rating Scale called MARS is the simplest way for classifying and assessing the quality of mHealth applications. It is an instrument reporting normative, reliability, and validity data of systems. [29], [30]

This is one possibility to evaluate applications in a meaningful way.

3) Verified content: Patients have to trust the provided information. It could have some health risks for them if wrong content is published. As shown in the Data analysis section redundancy and inconsistency are a problem with food tracking applications which are essential for people with diabetes or obesity. The provided information should be verified by professionals. The concept of "class instead of mass" is a good approach in this categorie of mobile applications. Another possibility would be the certification by a recognized organisation or performing a clinical evaluation.

In February 2015 the U.S. Food and Drug Administration (FDA) published the Mobile Medical Application document which regulates the usage of this eponymous term. They need exatly the same regulatory requirements as all medical devices. Actually, the FDA have an Enforcement Discretion in their document meaning the relinquishment of fulfillments of the regulatory requirements. [31]

On the FDA's website there are applications which follow the regulatory requirements. Therefore, their website is a meaningful source for trusted applications.

4) Transparency: The German Fraunhofer Instute for Information Security have developed a certification program called Zertapps, allowing mobile application developers to analyze and certify their products in the context of security risks. [32]

Thus, security problems should be eliminated, but in the case of missing information about the privacy policy in app descriptions or websites of the providers, only one solution exists. They would need to be obliged to provide information about the usage of the collected data in all categories such as type of information collected, rationale for collection, user controls or the sharing of information [27].

VI. Conclusion

Many people use mobile phones and there are a lot of applications available as shown in the first sections. The disease specific applications enable physicians to optimize medical treatments and diagnosis. Nevertheless, as seen from the Quality & Limits sections, applications have quality issues and serious problems with the security and privacy policies. This especially concerns the wellness management area which is also relevant for diseased people. These difficulties need to be overcome.

VII. Outlook

In this last section two near future opportunities of mHealth applications are shown.

One is the support for people with little or no chance for adequate medical treatments or diagnosis, especially in third world countries. Worldwide, there are over 1500 pilot projects. In Africa HIV is a disseminated problem and healthcare organisations fight against it with the support of mHealth software, e.g. with transmitted blood test data. [33], [34], [35]

Another very critical opportunity particularly in the context of this paper is the recent idea of German health insurance funds. Using sensor wristbands with their customers rewarding their fitness activities [36]. The collected data would then be be stored in patient charts to have an overview of their physical activities. To enable such applications privacy standards will have to be established. It needs to be ensured, that the collected data will only be used for medical purposes and not to optimize commercial benefits.

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