Published in proceedings of the 29th Bled eConference, Digital Economy 2016, Bled, Slovenia, 19-22 June 2016, which should be cited to refer to this work.

29th Bled eConference

Digital Economy

June 19 - 22, 2016; Bled, Slovenia

Healthy lottery. A design theory for a mobile system to increase compliance of individuals with diabetes

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Abstract

This article shows the preliminary results of an ongoing study to develop a system that financially rewards individuals with diabetes. Previous studies have already shown that monetary incentives appear to be the strongest motivator for older individuals with type II diabetes. Nonetheless, design criteria for a mobile service are not well established and there is no study available to assess the viability of a system that financially rewards individuals for self-management. Therefore, in this paper we explore a design theory that describes a new mobile service that integrates data from existing mobile application, and includes a self-supported lottery in a business model, which allows patients with effective self-management to be rewarded without any deficit. Our prototype is based on a social business model, which aims at improving patients' health and that can be described as "healthy" for them.

Keywords: diabetes, financial incentives, design science, business model

1 Introduction

This article is addressed to designers of diabetes management software, and more broadly to caregivers and patients affected by type II diabetes. We are interested in *diabetes management software* on smartphones or tablets, which helps persons with type I and type II diabetes manage the data associated with: (a) blood test results from a glucose meter, (b) manual log entries for exercise and other factors, (c) coaching for dose corrections.

Although there is a plethora of websites and mobile applications for individuals with type 2 diabetes, there is a scarcity of reliable data concerning their added value for older patients. In a recent review of internet-based interventions to promote lifestyle modification among adults with type II diabetes, the authors found that (a) successful studies had interactive components with tracking and personalized feedback and opportunities for peer support, (b) website utilization declined over time in all studies and concluded that future research is needed on the engagement of patients over time (Cotter et al., 2014). In fact, the successful use and potential health benefits related to the electronic devices seems to depend more on the design of the engagement strategies than on the features of their technology (Patel, Asch, & Volpp, 2015). To be effective, technologies must be paired with approaches that create and maintain engagemen**t** (Sen et al., 2014). Therefore, we sought a solution to improve self-management of older patients with type II diabetes, using mobile technologies and incentives to guide and maintain long-term engagement.

A recent review of diabetes apps for iOS and Android operating systems examined whether the available applications serve the special needs of diabetes patients aged 50 or older by performing an expert-based usability evaluation. The authors recommended that (a) patients and physicians alike should be involved in the app development process to a greater extent (b) the usability of diabetes apps for patients aged 50 or older was moderate to good, but this result applied mainly to apps offering a small range of functions (Arnhold, Quade, & Kirch, 2014). Another study conducted by (Volpp et al., 2008) demonstrated that mobile phone-based treatment and behavioral coaching intervention had a positive impact on the reduction of glycated hemoglobin levels over one year in patients with type II diabetes.

Previous studies have already shown that monetary incentives appear to be a strongest motivator for older patients affected by type II diabetes (Blondon, 2015). Nonetheless, there are no clear recommendations to design a mobile service and there is no study available to assess whether a system that financially rewards patients could be economically viable.

Therefore, our research question is: **how to design diabetes management software that uses financial incentives to increase patient's compliance?**

The rest of the paper proceeds at it follows. In section two, we briefly introduce the recent stream of research concerning financial incentives to increase patient's compliance. In section three we describe our design theory and in section four we illustrate an example to show how our mobile service could be financially viable. Section five concludes the paper and shows some directions for further investigation.

2 Literature review on financial incentives to increase patient compliance

According to behavioral economics, human judgments are biased and make it difficult for people to make self-beneficial choices. In this sense, it appears that people place more weight on the present than the future and therefore, immediate costs and benefits exert disproportionate influence on people's choices relative to those that will be experienced in the future. Accordingly, increasing the immediate rewards may influence people's propensity to act (Mitchell & al. 2013).

Studies on behavioral economics emphasize (1) the importance of frequent feedback and incentives (2) the motivational power of lotteries regarding other financial features (3) the motivation force of anticipated regret (Volpp & al. 2006). In particular, lottery rewards have been found to be effective as incentives in various fields of healthcare such as medication adherence, weight loss, cholesterol reduction, and vaccinations (Haisley et al., 2011).

Financial incentives for diabetes self-management have only begun to be explored. One study explored patients' perceptions and expectations of financial incentives to improve diabetes self-management, and found that individuals were optimistic about the effectiveness of incentives and expected financial incentives to be a stronger motivation for behavior change(Blondon et al., 2014). (Sen et al., 2014) confirm these findings by demonstrating that a lottery-based incentive improved monitoring rates among patients with uncontrolled diabetes. They found (1) similar efficacy relative to the amount according to the average gain possible (average daily reward 1.40$ or 2.80$) (2) the smaller expected value lottery was considerably more effective in the post-incentives period than the larger expected value lottery. Finally, in an online survey of 132 patients with diabetes, nearly all participants showed positive expectations about financial incentives. They favored financial incentives for behaviors they considered less challenging, and non-financial incentives for more challenging behaviors. This survey also enquired about the expected amount of incentives, in particular for a 5 lb weight loss, maintained over a year (Blondon, 2015).

3 Our design theory

Since we did not find a theory to design a system, which properly addresses our research question, we follow the guidelines of Gregor & Jones (2007) to describe the eight components of a design theory. In this section we describe the six core components, whereas in the next section we describe the two additional components.

Purpose and scope. As previously mentioned, the purpose of our mobile service is to increase the therapeutic compliance of patients with type II diabetes. We take into account that there are two sets of users: the younger patients, who are more familiar with smartphones and that have to plan their adult life taking into account their diabetes, and older patients, who might need assistance to use a smartphone and that, after the occurrence of diabetes, need to change a lifestyle, which they have been keeping for several decades.

Constructs. Our design theory has four constructs illustrated in figure 1. We use two constructs to describe the system, which (1) monitors the evolution of the patient's clinical situation and (2) that gives monetary incentives. The monetary incentives are measured by the money delivered to the patient, whereas we use two performance indicators to monitor the evolution of patient's clinical situation: (1.1) the patient's improvement in the short term and (1.2) the patient's sustainable change in the long-term. In this paper, the short-term improvement of the patient can be measured by the adherence to medication and the meetings with the caregiver, which are often reported in the patient's logbook. The sustainable change of the patient can be measured by mobile applications that monitor (a) the level of blood glucose, (b) the level of HbA1c and (c) the Body Mass Index. Finally, we propose to add one construct to assess the change in the caregiver efficiency, which can be measured by the average amount of hours spent with patients, and the motivation of the patient, which can be measured by the technology acceptance model (Venkatesh, Morris, Davis, & Davis, 2003).

Functions of the artefact. Figure 1 shows how the system works and represents the two functions of the system by using two rectangles. The caregiver and the patient affected by diabetes meet to set the goals, in terms of diet, exercise, medications and smoking cessation. We assume that the patient uses a set of devices to automatically collect data every data, whereas we also expect the caregiver to spend some time to set up the platform at the beginning (this assumption is based on mobile applications like myDiabeticAlert, which have two roles: patient and caregiver).

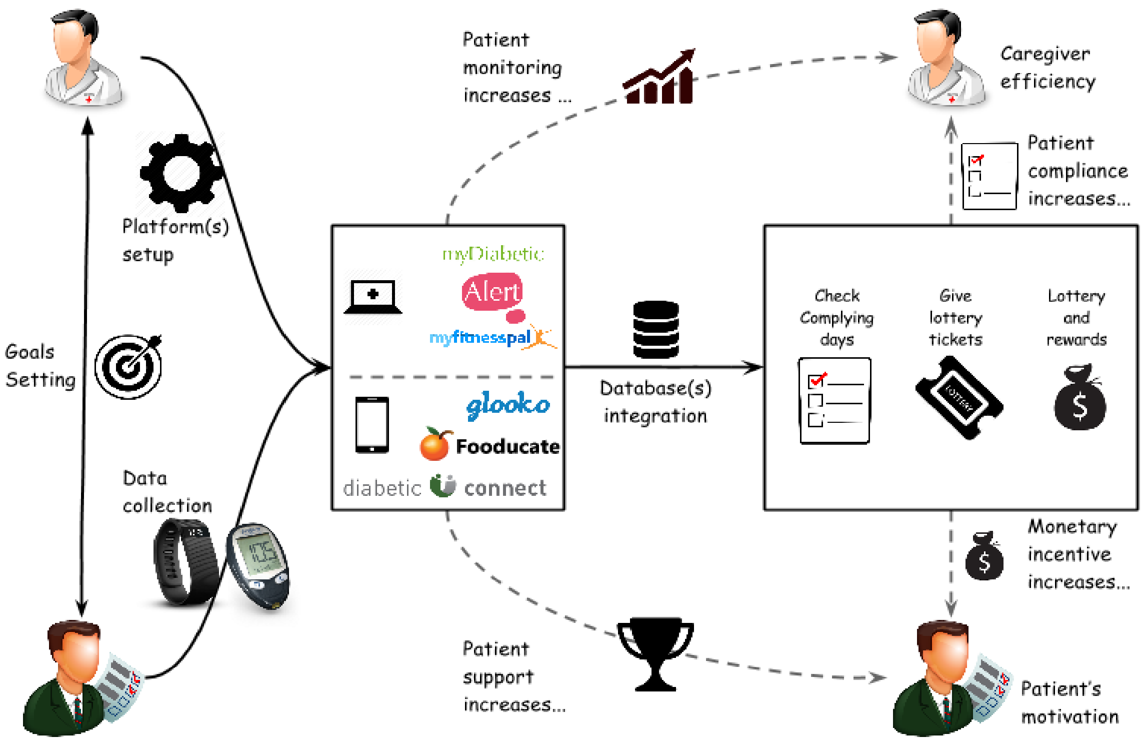

Figure 1: *Description of how goals are set, data is analysed, and rewards are given*

Our system gathers all the information collected by other mobile applications into one single database. We do not create our own mobile application, because we believe that there are already many that have a usable interface, a large community of users and a sufficient set of developers to maintain their constant improvement. Instead, we develop a back-end application that checks if the data is aligned with the goals, and assign a lottery ticket to each day the patient is compliant. At the end of each week, a lottery is done and the patient is notified of the result by email. A detailed explanation of how the second function of the system works can be found in the follow section.

Kernel theories. Our design theory extends the work of Blondon (2015) about financial incentives for patients affected by type II diabetes.

Testable propositions. By using our four constructs, we derive two sets of propositions. The first set concerns the effectiveness of our proposed solution, with respect to existing solutions. The second set of propositions assesses how our solution works.

- P1.1: *Monetary incentives* will decrease *patient HbA1c* in a greater amount than tested websites and mobile applications.
- P1.2: *Monetary incentives* will decrease *patient BMI* in a greater amount than tested websites and mobile applications.
- P2.1: *Monetary incentives* will increase *patient's motivation* in a greater amount than tested websites and mobile applications
- P2.2: *Monetary incentives* will lower *caregiver time spent per patient* in a greater amount than tested websites and mobile applications

Artefact mutability. The lottery system allows every patient, who tries to comply, to havea high chance to win something over the year. Indeed, a patient that complies only for one day gets already a lottery ticket and eventually will win once. Nonetheless, the system penalizes the patients who comply to win money. Indeed, if all patients fully comply, each one of them will get back the money that was initially spent. Hence, patients that are motivated only by money will stop complying and will earn less money over time. Although our system is conceived for older patients with type II diabetes, it would be reasonable to presume that the system would work with younger patients with type II or even type I as well. Some adaptations should be included, e.g., stronger social media component to share results and support online, but most of these requirements are already fulfilled by existing applications for smartphones. A possible extension of the system described in figure 1 allows for a sophisticated business model, which would include an additional set of participants to cover insurance costs without the need of insurance firms. Nonetheless, for sake of simplicity, we do not discuss this extension in this paper.

4 How to design a profitable mobile application by following our design criteria

In this section, we describe how to implement the lottery function of our system and we offer an illustratory instantiation by means of a simple example. In the fourth column of table 1, we assign fictive values to a set of variables, which are listed in the first column and that are needed to assess the revenue model of our service.

Variable	Code	Formula	Values	Comments
Number of participants	N	N	100	We assume to have 100 participants
Weekly inscription price	WIP	WIP	$1	Each patient pays in advance and has to comply all the week to expect to get the money back.
Weekly revenues	WR	N*WIP	$ 100	By assuming that there are 100 participants, every week the system handles $100
Financial support from insurances	FSI	FSI	$ 0	In this example, the insurance of the patient is assumed to not sponsor this system.
Total revenue	TR	WR + FSI	$ 100	The weekly revenue totally depends on the number of participants.
Profit	P	5%	5%	A percentage of the revenue is taken by the system to cover its costs
Total game revenue	TGR	TR*(1-P)	$ 95	Every week, $95 is distributed across the patients that complied.
Expected Compliance	EC	E	3	Each patient is expected to comply 3 days per week on average
Winning probabilities	P	P	7	If the patient complies every day, the system delivers 7 tickets every week
Expected winners	EW	N*EC/P	43	Since the average probability to win is 3/7, the number of winners is assumed to be 43
Rewards	Y	TGR / EW	$2.21	In the end, a complying participant, who paid $1, should expect to receive $2.21 dollars.

Table 1: *Example of a lottery system auto-financed by 100 patients with diabetes type II*

Table 1 shows how to assess the profitability of the system. Indeed, in our illustratory example, a complying participant is expected to earn 2.2 times what was initially spent, whereas the platform can cover its cost to not lose money at the end of the year.

Such results can be explained by the fact that each winner receives money from those who did not comply. Therefore, this approach is similar to the “speed camera lottery” (Sorrel, 2010), which gave to each car driver, who respected the speed limits, a ticket for a lottery made with the fees paid by the non-compliant drivers.

We believe that the random rewards delivered by e-mail will motivate the patients without requiring any additional effort on their side. Moreover, we suggest that a system that increases patients’ self-management on the long term will be more efficient than a system that simply shares the patient’s data with the doctor.

5 Discussion and conclusions

This article illustrates the preliminary results of an ongoing study that aims at designing diabetes management software, which uses financial incentives to increase patient compliance.

By following the guidelines for a design theory, we have described a system that combines existing mobile applications to deliver a new service and we explained how to implement a self-supported lottery with a business model that rewards compliant patients without financial deficit.

Our theory requires empirical testing to confirm its validity, and our interviews with field experts led us to be attentive at the ethical implications of the abuses of such a system. For that reason, we have decided to call our system “healthy lottery”.

Nonetheless, we believe that our research opens new interesting directions of investigations with financial rewards to improve patient compliance, which may also apply to other chronic diseases other than diabetes. Future research could also explore our proposed design of a self-supported lottery as a device for behavioral change.

Acknoledgements. *The authors would like to thank Michaël Poli for his useful insights, while developing the quantitative model described in table 1.*

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