Mobile Devices as Support Systems for Health Behaviour Change

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***Abstract*—A Behaviour Change Support System (BCSS) is a socio-technical information system designed to form, alter, or reinforce attitudes, behaviours, or compliance to a regular patterns of activities, and they do so without the use of coercive or deceptive elements. A health BCSS (HBCSS) is then a BCSS aimed at influencing health behaviours and wellbeing in a positive way. Accordingly, mobile devices can represent ideal tools to become the enabler portals for HBCSS. In this research we provide a review of the literature on mobile applications to see if and how they can be classified as HBCSS. We focus our review on Type 1 Diabetes and emphasize on whether persuasive elements are used and, if so, how. This in turn will aid us to assess what is required for mobile devices to become HBCSS.**

Keywords—mobile devices; persuasive design; behavioural change support systems; Type 1 Diabetes

I. INTRODUCTION AND BACKGROUND

A Behaviour Change Support System (BCSS) is defined as "a socio-technical information system with psychological and behavioural outcomes designed to form, alter or reinforce attitudes, behaviours or an act of complying without using coercion or deception" [1] A health BCSS (HBCSS) is then a BCSS aimed at influencing health behaviours and wellbeing in a positive way. Accordingly, mobile devices represent ideal tools to become HBCSS. In this paper we provide a review of the literature on mobile applications dealing with Type 1 diabetes to assess whether persuasive elements are used, and if so how. This in turn will aid us to assess what may be required for mobile devices to become HBCSS.

A. Mobile Devices as Main Portals to Socio-Technical Information Systems

A socio-technical system (STS) is a social system that is supported by a technical or technological system. For an STS to exist, there are few elements that need to be in place: (1) hardware; (2) software; (3) individual people; and (4) a community of people (See Figure 1). Prior to the emergence of mobile devices, desktop computers were the primary enabling tools through which people participated with and within STS. In recent times, people are shifting to mobile devices, and as they become increasingly pervasive, these devices will be the main portal which will enable people's participation in STS. They will provide individuals with increasing opportunities to join and be active in STS, as exemplified with the growing emphasis of Facebook and Twitter to move from their desktop platform to the mobile one. With enhanced mobility and tailored for high personalisation of interaction, people are spending more time on these devices than on desktops / laptops, and this trend can turn mobile devices into catalyst tools that will enable people to become more involved in STS. Health and wellbeing are issues that are galvanizing attention, particularly within younger population, who are likely to own at least one mobile device.

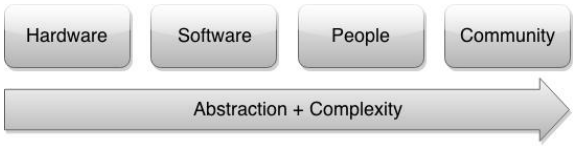

Fig 1. Elements in a socio-technical system

B. Mobile Devices as an Integral Part of the Ecology Of Persuasive Systems

Oinas-Kukkonen and Harjumaa [2] describe that persuasion of BCSS, to be effective, has to be incremental and use direct and indirect approaches, and that persuasion systems should aim to be (1) unobtrusive, (2) open, and (3) useful and easy to use. Mobile devices can lend themselves suitably to be an integral part of the ecology of a persuasive BCSS.

Incremental persuasion strategies could be more effective when personal data are available. Mobile devices, unlike desktop computers, offer convenient ways for people to enter and update their personal and private data. In addition, the embedded sensors are able to capture an incredible rich amount and variety of data and, when combine with suitable data mining techniques, it is possible to determine patterns conducive to healthy living (and otherwise) in an automated yet unobtrusive manner [3] When patterns leading to possible future unhealthy conditions are detected, the system through a mobile device can issue messages or cues of progressive or incremental persuasiveness and which can be designed based on the intended outcomes and types of change [1] It is in this light that mobile devices can make the provision of progressive persuasion tailored to individuals.

C. *Mobile Devices and Self-Regulation*

The end goal of HBCSS is to form, alter and reinforce attitudes and behaviours. In the context of health, this habit of forming, alteration, and reinforcement necessitates self-management—in other words, it requires the exercise of motivational and self-regulatory skills. Self-management can refer to "tasks that an individual must undertake to live well with one or more chronic conditions (see Figure 2 below). These tasks include gaining confidence to deal with medical management, role management, and emotional management" [4]. Maes and Karoly [5] conceptualise self-regulation as a three step process by which individuals bring their influence to bear on their health habits. In their model, goal adoption sets the stage for self-directed change; implementation strategies convert goals into productive actions; and maintenance strategies help to sustain achieved behavioural changes. In between these stages, people will need to have (1) an awareness of health risks and benefits of health practices as well as goals to attain, (2) concrete plans and strategies for realising them, (3) ways to continuously help them to assess their progress, and (4) confirmation and confidence of their progress to update previous goals or set new ones.

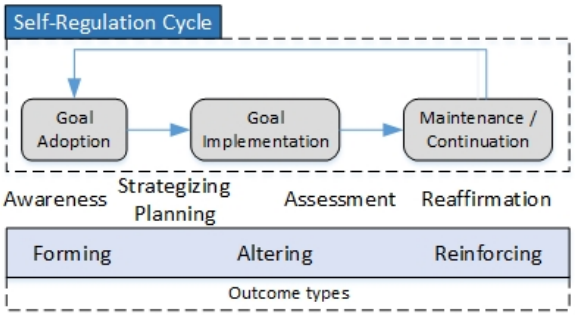

Fig 2. The self-regulation cycle mapped onto the outcome types of BCSS.

In each of the three steps, persuasion is integral. Any BCSS would need to have persuasive mechanisms to motivate people to learn about health risks and benefits of health practices, to plan how they can attain a set goal, to keep assessing continuously their health situation to see how close they are to their goal, and finally to have reassurance that they would want to continue to sustain any acquired behaviour or attitude.

Self-regulation processes are inherently data intensive, requiring acquisition, storage, and analysis of large amounts of data often on a regular basis. These are low level activities that are best performed as automatically as possible by the system. Computer-supported approaches using motivation and persuasion elements have been shown to be effective in encouraging healthful lifestyles in terms of weight reduction and smoking cessation [6] [7] [8] [9]. These systems are well-received because they are individually tailored to people's needs and can provide continuous personalised guidance that empowers people to adopt healthy behaviours in a gradual way. Before mobile devices became sophisticated, desktop computers had been the main medium used to motivate and guide self-directed change. By linking the interactive aspects of the self-management model to the Internet, one can vastly expand its availability to people wherever they may live, at whatever time they may choose to use it. The biggest issue of computers is mobility and portability. The arrival of mobile devices has solved this; to increasing further personalisation and facilitating data capture, storage, analysis, and presentation.

Today's mobile devices, with their sophisticated sensing and computing capabilities, are touted as better tools to be used for persuading people to adopt self-regulation activities and, more importantly, supporting them along the process with their ease of use and 'intelligent' [10]. Mobile device based BCSS that are personalised, intelligent, and persuasive can be common place in the future. Although research on patient-operated mobile self-regulation tools has exhibited relatively strong growth in recent years, it is still rather immature. As such, it is unclear whether there is evidence that mobile devices are moving towards this envisioned role. Due to a proliferation of mobile phone applications that claim to help improve people's lifestyles and health, it seems important to see how current applications are being used and their usefulness to people with a health condition to support their self-manage and reorganise their lifestyle. In this paper, we focus our attention to one particular condition: *Type 1 diabetes*.

II. DIABETES SELF-REGULATION SUPPORT SYSTEM

A. *Type 1 Diabetes*

Type 1 diabetes is a condition related to the incapacity of the pancreas to produce insulin due to an autoimmune disorder [11]. In recent years, and the incidence and prevalence of this Type 1 diabetes in young people is increasing [12] [13]. If not diagnosed and treated, Type 1 diabetes can cause serious complications for children such as weight loss, delays in pubertal and skeletal maturation, nephropathy, hypertension, glycosuria, diabetic ketoacidosis and hypoglycaemia, just to name a few [14] [15] [16]. All these complications deteriorate the quality of life of young patients and can even cause death [17] [18].

Type 1 diabetes cannot be prevented but it can be managed through a combination of medication, healthy food choices and exercise. Since there is no available cure for Type 1 diabetes, children with this chronic condition require, as part of their treatment, lifelong insulin injections in order to maintain their normal blood sugar levels and avoid complications [19]. However, only half of all patients with chronic diabetes comply with treatment regimen [20] [21]. Self-regulated behaviours, therefore, aim to systemize a conscious approach to personal health management including goal-setting and goal attainment; impulse control, the management of short-term goal; deliberately monitoring one's own behaviour and evaluating how this behaviour affects one's health.

There are two reasons Type 1 diabetes has been chosen for this research. The first reason is because of the growing number of affected people due to today's heavy sugar reliant diet and sedentary lifestyles; the second is that there is a plethora of applications claiming to help patients self-manage their condition.

The study reviews mobile applications reported in peer-reviewed articles and/or from commercially available mobile applications. The objective is to determine, in a systematic review, whether diabetes applications have been helping patients with diabetes to self-manage their condition, to self-regulate their behaviour, with a particular focus on whether persuasive elements are used and how. From a practical perspective, the results of the analysis highlight key features and requirements for diabetes self-management applications as HBCSS. From a theoretical perspective, the results identify research gaps and help outline an agenda for research related to various factors for improving the adoption, usability, and integration of diabetes self-management applications in the patients' daily routine.

III. METHODS AND RESULTS

We approach this study by reviewing related articles in peer-reviewed journals. In addition, we survey both commercial and non-commercial mobile applications dealing with Type 1 diabetes. Our review of papers included more than 100 papers, and more than 30 applications

A. Mobile Device Based Diabetes Self-Regulation.

Recent advances reflected in these clinical guidelines [22] [23] recommend the following six features as part of important variables for diabetes self-management: (1) Education and personalized assessment / feedback; (2) Diet management, Weight management, Physical activity; (3) Communication and patient monitoring by primary care providers; (4) Insulin and medication management; (5) Other therapeutics (foot and eye care), Psychosocial care, Immunization and (6) Complication management. These features can be mapped onto known symptoms of the condition, treatments and lifestyle changes, and needs of people with the condition.

A. Relevant Features to Mobile Device HBCSS

The following three features are of particular relevance to mobile devices.

Education and personalization: Research has provided adequate proof that self-management education has a positive impact on clinical outcome [24]. There are many commercial applications with the majority providing general diabetes education—e.g., guideline for diabetes care, food information, videos about diabetes, and expert questions and answers. However, just providing a repository of information is not enough. The most challenging aspect is to persuade people, who may have or will have the condition, to begin the process of educating (or often re-educating) themselves about it, to better understand themselves and their condition. When persuasion is tailored to a particular individual, which in the case of diabetes could be based on the patient's profile, the patient context and education, and the goals of the medical treatment process [25], it could have enhanced effectiveness [26].

Decision Support: Analysis and rule-based interpretation of data on an individual basis is essential if the system is to support change in habit and attitude in a sustained manner, especially when done automatically [27]. With mobile devices, people could be tempted to check the tools to support their decision making process. In addition, the devices can provide alerts or reminders about actions to take based on pre-set patterns and schedules. This level of support is possible with such devices.

Communication: In terms easiness of communication, mobile devices have revolutionised the field. Data captured and stored in devices can be sent to clinicians, certified professionals, or trusted guardians (in the case of children [28]) to review. The responses can be sent back and received with equal ease. Automated alerts, a type of persuasion, can make it easier for patients to self-manage their condition.

The literature offers little about how persuasive elements are included in mobile device tools for management of diabetes. Surveys by Arsand et al. [29] have mainly focused on interface features and usability of mobile diabetes management applications, and not so much on persuasion elements.

These surveys show that there seems lack of emphasis on education, especially in a personalised way—this is perhaps due to the assumption that there is already significant amount of information, in particular online, out there that people peruse. Decision support is available, but that widespread yet—for example, Garcia [30] noted that only some iPhone-based applications provide some kind of decision support. Although social media forums have grown very rapidly, they are not mainstream in diabetes applications.

Another interesting finding is that most of these applications are based on manual entry of data such as blood glucose levels and weight, while 16 of the 26 applications found in the literature used wireless (Bluetooth, ZigBee, or Wi-Fi) automatic data acquisition. Wireless sensors are now widely available, but proprietary rights and vendor restrictions hamper their use in some commercial markets (e.g., Apple iPhone). This we believe is a big impediment for a wider mobile applications, as manual data input not only exposes the user to erroneous input, but it can also be a daunting task and may lower compliance [31].

One more noteworthy finding is about alerts, which are not used often. Alerts could be one of the most useful features of mobile applications, similar to reminders for meetings from calendar applications. This is an aspect that persuasive mobile systems can make use.

Usability issues are important and any BCSS should get those right; otherwise patients will simply not use them [32]. BCSS ought to be more than usable; they will need patients to appreciate the need to use them and see how they fit into their lives.

Non-functional requirements: There are also non-functional requirements to consider, especially about the perceived credibility of the system. One of the major issues in diabetes applications is security. When offering suggested for what approach to use, the system should ideally be presenting those endorsed and with proven success. When data is entered by the patient or captured automatically, they should be checked speedily by suitable analytics tools in the

first instance and, if there is need, by a professional expert so that further guidance is returned to the patient.

As stated earlier, very few applications have social media capabilities, and this is an area that can be expanded and exploited. Patients often need moral and psychological support. Sympathy, understanding, and compassion from other patients and people can be an important motivating factor for the early exploration and adoption of a system. During the planning stage, sharing of successful approaches and facilitation by people within the social circle could be very persuasive and inviting. If this is followed by further continuous encouragement and support as well as healthy comparison with others who follow the same approaches would further consolidate a new acquired behaviour.

IV. SUMMARY AND FUTURE RESEARCH DIRECTIONS

In this paper we provide a review of the literature on mobile applications dealing with Type 1 diabetes to assess whether persuasive elements are used, and if so how. This is to assess what may be required for mobile devices to become HBCSS. We presented the findings by reviewing related articles in peer-reviewed journals as well as surveying both commercial and non-commercial mobile applications dealing with Type 1 diabetes.

Further, a mobile devices to become HBCSS it may be pertinent to develop description of a user, that is, a user model. This is primarily to predict user responses, thereby creating more effective, efficient and personalized interactions by tailoring system responses to individual preferences. Systems that incorporate user models have been traditionally termed “intelligent systems” because a representation of the user is created by the system and is used to reason about the user’s information need and document preferences [33]. The system then uses the information that has been collected about the user to personalize interactions.

As stated earlier, very few applications have social media capabilities, and this is another area that can be expanded and exploited.

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