Can J Diabetes 40 (2016) 95–104

Contents lists available at ScienceDirect

Canadian Journal of Diabetes

journal homepage: www.canadianjournalofdiabetes.com

Review

The Systematic Design of a Behavioural Mobile Health Application for the Self-Management of Type 2 Diabetes

Shivani Goyal MSc [a,b,*], Plinio Morita PhD [a], Gary F. Lewis MD [d], Catherine Yu MD, MHSc [e,f], Emily Seto PhD, PEng [a,c], Joseph A. Cafazzo PhD, PEng [a,b,c]

[a] Centre for Global eHealth Innovation, Techna Institute, University Health Network, Toronto, Ontario, Canada
[b] Institute of Biomaterials and Biomedical Engineering, University of Toronto, Toronto, Ontario, Canada
[c] Institute of Health Policy, Management and Evaluation, Faculty of Medicine, University of Toronto, Toronto, Ontario, Canada
[d] Departments of Medicine and Physiology, Division of Endocrinology and the Banting and Best Diabetes Centre, University of Toronto, Toronto, Ontario, Canada
[e] Division of Endocrinology & Metabolism and Li Ka Shing Knowledge Institute, St. Michael's Hospital, Toronto, Ontario, Canada
[f] Faculty of Medicine and Dalla Lana School of Public Health, University of Toronto, Toronto, Ontario, Canada

ARTICLE INFO

Article history:
Received 2 December 2014
Received in revised form
23 April 2015
Accepted 17 June 2015

Keywords:
blood glucose
diabetes mellitus
lifestyle
mobile health
self-management

ABSTRACT

Patients with diabetes often face serious complications due to limited self-management skills, the inability to adhere to care regimens, and psychosocial factors. Although regular self-monitoring of blood glucose is known to benefit patients receiving insulin therapy, its role in patients not treated with insulin has been unclear. However, recent studies have demonstrated that structured self-monitoring of blood glucose can significantly benefit patients who are not taking insulin, facilitating improved self-awareness and clinical decision making. We hypothesize that effective self-management by patients with type 2 diabetes who do not need insulin requires a behavioural intervention that enables the association between lifestyle behaviours, such as dietary intake and physical activity, and overall glycemic control. Mobile health applications (apps), coupled with wireless medical peripheral devices, can facilitate self-monitoring; deliver tailored, actionable knowledge; elicit positive behaviour changes and promote effective self-management of diabetes. Although existing apps incorporate tracking and feedback from healthcare providers, few attempt to elicit positive behaviour changes for the purposes of developing patients' self-care skills. The purpose of this article is to present a systematic approach to the design and development a diabetes self-management mobile app, which included 1) a scoping review of literature; 2) the development of an overarching theoretical approach and 3) validation of the app features through user-centred design methods. The resulting app, bant II, facilitates 1) self-monitoring of blood glucose, physical activity, diet and weight; 2) identification of glycemic patterns in relation to lifestyle; 3) remedial decision making and 4) positive behaviour change through incentives.

Mots clés:
A1c
glycémie
poids corporel
diabète sucré
régime alimentaire
mesures incitatives
mode de vie
santé mobile
activité physique
prise en charge autonome
conception de logiciels

RÉSUMÉ

Les patients diabétiques font souvent face à des complications sérieuses en raison de leurs compétences limitées sur la prise en charge autonome, de leur incapacité à suivre des programmes de soins et de leurs facteurs psychosociaux. Bien que l'autosurveillance régulière de la glycémie soit connue comme étant bénéfique aux patients qui reçoivent une insulinothérapie, son rôle chez les patients qui ne sont pas traités par insuline est demeuré obscur. Cependant, de récentes études ont démontré que les patients qui ne prennent pas d'insuline peuvent grandement bénéficier d'une autosurveillance structurée de la glycémie, ce qui facilite l'amélioration de la conscience de soi et la prise de décision clinique. Nous posons l'hypothèse que la prise en charge autonome efficace des patients souffrant du diabète de type 2 qui n'ont pas besoin d'insuline exige une intervention comportementale qui permet l'association entre les comportements liés au mode de vie, comme l'apport alimentaire et l'activité physique, et la maîtrise globale de la glycémie.

Les applications mobiles en santé (applis) combinées aux périphériques médicaux sans fil peuvent faciliter l'autosurveillance; fournir des connaissances concrètes personnalisées; susciter des changements positifs de comportement; promouvoir une prise en charge autonome efficace du diabète. Bien que les

* Address for correspondence: Shivani Goyal, MSc, Centre for Global eHealth Innovation, Techna Institute, University Health Network, Toronto General Hospital, R. Fraser Elliott Building, 4th Floor, 190 Elizabeth Street, Toronto, Ontario M5G 2C4, Canada.
E-mail address: shivani.goyal@uhn.ca

1499-2671
http://dx.doi.org/10.1016/j.jcjd.2015.06.007

applis actuelles incorporent le suivi et la rétroaction des prestataires de soins, peu suscitent des changements positifs de comportement aux fins de développer les compétences d'autosoins des patients. L'objectif du présent article est de présenter une approche systématique pour la conception et le développement d'une appli mobile sur la prise en charge autonome du diabète, qui comprenait : 1) une revue exploratoire de la littérature; 2) le développement d'une approche théorique globale; 3) la validation des caractéristiques de l'appli par des méthodes de conception centrées sur l'utilisateur. L'appli engendrée, bant II, facilite : 1) l'autosurveillance de la glycémie, de l'activité physique, du régime alimentaire et du poids; 2) l'identification des profils glycémiques en rapport avec le mode de vie; 3) la prise de décision pour y remédier; 4) le changement positif du comportement au moyen de mesures incitatives.

Introduction

Diabetes mellitus is 1 of the most prevalent chronic diseases worldwide. It is estimated that more than 382 million individuals are living with diabetes, with approximately 2.4 million of those patients residing in Canada (1,2). Consequently, an overwhelming number of these patients face the serious complications of diabetes, resulting in hospitalizations, exhaustive use of resources and diminished quality of life. The failure to meet clinical targets is multifactorial and often includes limited self-management skills, lack of adherence to diabetes care regimens and psychosocial factors.

Currently, only half of the patients with type 2 diabetes mellitus are achieving glycated hemoglobin (A1C) levels below 7% (3). Although self-management has long been acknowledged to be a key component in the clinical treatment of diabetes, patients often lack the knowledge and skills necessary to manage their condition on a daily basis (4). The inability to understand the fundamental impact of diabetes-management activities on overall glycemic control leads to low levels of participation in self-care behaviours (4,5). This is particularly problematic for patients with type 2 diabetes who are not treated with insulin and who are typically prescribed lifestyle modifications and pharmacotherapy because they have no daily indicators of glycemic control.

Self-monitoring of blood glucose (SMBG) is an essential component of insulin therapy regimens, but its role in patients not treated with insulin has been unclear (6). However, recent studies have demonstrated that structured SMBG, an approach in which the frequency and timing are predetermined, can significantly improve glycemic control and overall patient engagement (7–9). With the appropriate guidance and education, SMBG can improve self-awareness and motivate patients with type 2 diabetes who are not taking insulin to participate in self-management activities that can control diabetes (10).

Some patients may receive diabetes education, but the training is generally infrequent, impersonal and difficult to apply to real-world settings (5). As a result, patients are unable 1) to understand and apply guidelines to their individual and unique situations; and 2) to understand the functional dynamics of glycemic control and recover from exceptional situations (5). These 2 factors can significantly impact diabetes self-management because, in addition to routine self-care, the ability to solve problems and make decisions based on blood glucose levels can significantly reduce long-term complications for patients with diabetes (11).

The self-management tools currently available are didactic and do not provide patients with the personalized and actionable knowledge needed to participate in routine self-care (12). Although the increasing prevalence of the use of mobile phones has resulted in the publication of many diabetes applications (apps), most are not evidence based or rigorously evaluated, and many rely on real-time feedback from third-party healthcare providers (12–15). We hypothesized that effective self-management by patients with type 2 diabetes who do not need insulin requires a behavioural mobile health (mHealth) app that empowers patients with the ability to self-monitor, understand the impacts of lifestyle behaviours on glycemic control and adjust their self-care based on contextualized data.

In this article, we present the systematic design and development of bant II, a mobile self-management app for patients with type 2 diabetes not treated with insulin. This process included 1) a scoping review of literature focused on self-monitoring aspects of diabetes management; 2) the development of an overarching framework; 3) the identification of an underlying behaviour-change theory; 4) translation of the identified knowledge into app features and 5) validation of the features through user-centred design methods.

mHealth for diabetes self-management

Mobile phones have become a ubiquitous electronic tool in daily consumer transactions, such as communication, shopping and even access to health-related information, fundamentally transforming the way society members interact with the world around them. Recently, mobile phone-based telemedicine has proven to be an effective approach for information exchange and for providing feedback between patients and their caregivers. However, both are heavily dependent on third-party healthcare providers (HCPs) to facilitate real-time feedback (12,15,16). For example, the WellDoc study, a cluster randomized clinical trial involving 163 patients with type 2 diabetes, demonstrated that a multifaceted mobile-phone system with third-party feedback reduced A1C levels up to 1.9% in the intervention arm (15). However, the involvement of the HCPs in this study was critical for achieving the outcome, and the associated cost of this additional resource is of major concern in terms of access and long-term sustainability (54).

Mobiles phones are inherently personal communications devices with powerful computing and touch-based user interfaces. They can be used to deliver self-management tools that are embedded into the daily routine of individuals and to facilitate habitual self-monitoring (12,14,17). However, in order to elicit behaviour change, the design of mobile apps requires a thoughtful, patient-centred and evidence-based approach (14). For example, we conducted a randomized clinical trial (n=110) among hypertensive patients with type 2 diabetes in which, in addition to standard care, the intervention group received mobile phones loaded with a self-management app and wireless blood pressure cuffs, and the control group received regular blood pressure cuffs plus standard care. At 12-month follow up, the intervention group demonstrated a significant decrease in ambulatory systolic blood pressure of 9.1±15.6 mm Hg, and the control group saw no change (18). The user-centred mobile system facilitated behaviour change by these patients without regular third-party HCP feedback or additional visits to family physicians (18). Similarly, we hypothesized that a well-designed mHealth intervention coupled with SMBG could also achieve improved clinical outcomes. The proposed mobile app, bant II, could potentially eliminate the need for active third-party HCP feedback, significantly lowering the cost of the intervention and greatly expanding access.

The vast majority of existing mHealth apps not only lack any use of theoretical models for behaviour change but also have no clinical evaluation to validate their approaches (19). The limited use of frameworks in this field has resulted in mHealth technologies that are most often not intuitive, useful or evidence based. In order