

Assessment of Rwandan diabetic patients' needs and expectations to develop their first diabetes self-management smartphone application (Kir'App)

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Abstract

Background: Knowledge of and coping with diabetes is still poor in some communities in Rwanda. While smartphone applications (or apps) have demonstrated improving diabetes self-care, there is no current study on the use of smartphones in the self-management of diabetes in Rwanda.

Methods: The main objective of this study was to assess the needs and expectations of Rwandan diabetic patients for mobile-health-supported diabetes self-management in order to develop a patient-centred smartphone application (Kir'App).

Results: Convenience sampling was used to recruit study participants at the Rwanda Diabetes Association. Twenty-one patients participated in semi-structured, in-depth, face-to-face interviews. Thematic analysis was performed using Mayring's method of qualitative content analysis.

Conclusions: The study included 21 participants with either type 1 (female = 5, male = 6) or type 2 (female = 6, male = 4) diabetes. Participants' age ranged from 18 to 69 years with a mean age of 35 and 29 years, respectively. Eight main themes were identified. These were (a) diabetes education and desired information provision; (b) lack of diabetes knowledge and awareness; (c) need for information in crisis situations; (d) required monitoring and reminder functions; (e) information on nutrition and alcohol consumption; (f) information on physical activity; (g) coping with burden of disease, through social support and network; (h) app features. This study provides recommendations that will be used to design the features of the first Rwandan diabetes self-management smartphone application (Kir'App). The future impact of the application on the Rwandan diabetic patients' self-management capacity and quality of life will be evaluated afterwards.

Keywords: diabetes, Kir'App, Rwanda, smartphone application

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Diabetes care in Rwanda

Approximately 425 million adults (age 20 to 79 years) have diabetes worldwide.¹ In 2045, this number is expected to rise up to 629 million. In Africa, the number of patients with diabetes is expected to rise from 16 to 41 million (+156%). According to the World Health Organization, 2.8% of the Rwandan population are estimated to have diabetes.²

Rwanda's community-based health insurance system covers 80% of the population (2015–2016) and is further improving towards universal health coverage of the country. The healthcare system also covers country's poorest citizens through its home-grown development programme that aims to lift the living standards of poor families and to facilitate their access to healthcare.^{3,4} Although Rwanda's national programmes ascertain general

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access to healthcare, knowledge and perception of diabetes mellitus is still inadequate in some communities of the country.⁵

Evidence on diabetes self-management

Strategies to provide education and support, for example, diabetes self-management education (DSME) programmes, for patients with type 2 diabetes mellitus (T2DM) incorporate ongoing self-monitoring of glucose levels and other diabetic outcomes as well as setting of behavioural goals. Behaviour change on the basis of these goals is the primary aim of DSME interventions,⁶ for example, regular intake of fruit and vegetables or increased levels of physical activity. Recent evidence from a pre–postparallel group design study indicates that self-management reduces diabetes mellitus (DM)-associated comorbid conditions as well as healthcare utilization and, therefore, overall cost.⁷ According to a meta-analysis of eight studies, DSM improved DM-related quality of life.⁸ Mezuk and colleagues found significant improvements of glycated haemoglobin (HbA1c) through self-management in a group setting in which lay healthcare workers served as coaches.⁹ All in all, evidence suggests that patient empowerment and behaviour change through self-management support is crucial for the success of DSM.

Self-management demands continuous medical support, as well as monitoring of disease-specific parameters. It is therefore regarded as the ideal target for telemedicine interventions.^{10–12} The International Diabetes Federation (IDF) published six categories of mobile applications (or apps) used in diabetes management.¹³ This includes tracking of medical parameters (e.g. blood pressure, blood glucose, body weight, etc.), nutrition (healthy food choices) and fitness data (physical activity) to support improved self-management and healthy lifestyle. They also call for a strengthening of patient relationships with their friends and families using social networks and blogs. Recent analysis shows mixed results for quality, reliability and privacy of available apps, making it hard for clinicians to recommend appropriate ones to their patients.¹⁴ In Rwanda, Kateera and colleagues have published a study proposing the introduction of mobile health (mHealth) approaches in the management of noncommunicable diseases, including diabetes.¹⁵

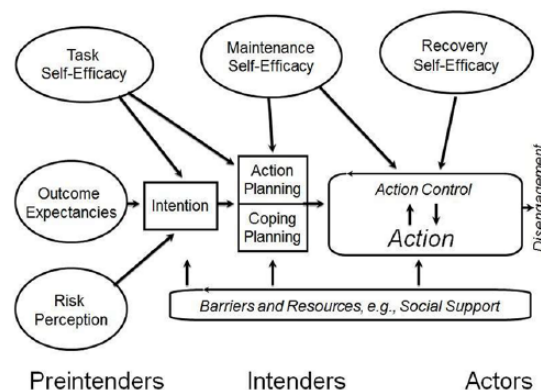


Figure 1. The HAPA model.¹⁸

Several preconditions have to be met for preintenders to become intenders and start planning an activity. The same is true for maintaining this activity (action stage). HAPA, Health Action Process Approach.

Theory-grounded development and implementation of behaviour-change interventions

Due to the varying backgrounds, needs and preferences of patients with chronic diseases, the whole process of planning, design and the implementation of the included technologies should be user-centred.^{16,17} Therefore, knowing and understanding the individual's predispositions towards health behaviour change is of high importance when planning and for innovation. Theories and models of behaviour change provide guidance in this endeavour. Developed by Ralph Schwarzer in 1992, the Health Action Process Approach (HAPA) combines evidence-based theories, such as the Theory of Reasoned Action, the Theory of Planned Behaviour and the Health Belief Model. Its major contribution to health behaviour research is the inherent recognition that behaviour change has to be maintained over time. Both the intention (action planning) as well as keeping up the healthy behaviour (action) depend on several predictors, as shown in Figure 1.

A meta-analysis on the effectiveness of the Health Action Process Approach (HAPA) in predicting health behaviour change in chronically ill patients showed an overall fit of the model. Small-to-moderate effects were found for self-efficacy beliefs in the planning as well as in the volitional phase, whereas risk perception (vulnerability) showed only small effects. No effect was found for social support.¹⁹ Physical activity among adults with T2DM can be predicted by the

Table 1. Objectives of our study.

Primary objective	To identify needs and expectations of Rwandan diabetic patients for a potential diabetes self-management smartphone application (Kir'App).
Secondary objectives	To identify functions which need to be delivered by a potential diabetes self-management smartphone application (Kir'App) to assist patients in their daily disease management. To translate participants' expectations into recommendations for the development of the intended diabetes self-management smartphone application Kir'App.

HAPA, with self-efficacy again being among the most important predictors.²⁰ There is also evidence that the use of apps has a positive effect on the social-cognitive predictors of the HAPA for individuals engaging in physical activity.²¹ Based on this evidence, the HAPA is a suitable starting point for the interpretation of the results of the current study.

Objective

The objectives of the study are presented in Table 1.

The presented research is part of a research project called 'Kir'App Rwanda diabetes study' aiming to develop the first Rwandan diabetes self-management smartphone application.

Method

Study design

A qualitative study design was employed.

Target population

The target population of the study were Rwandan patients with type 1 and type 2 diabetes registered with the Rwanda Diabetes Association (RDA) at the time of the study.

Participants and eligibility criteria

The inclusion criteria for participating in the study were defined as being Rwandan, aged 18 years and above, living with type 1 or type 2 diabetes, registered with the RDA and having daily access to a smartphone.

Data collection tool and pilot test

Semistructured face-to-face in-depth interviews (February to March 2018) were used to collect

the data. The interview guideline was developed based on the methodology of in-depth interviews²² the authors' research background and experience in diabetes care as well as IDF guidelines and protocols for diabetes care.¹

The interview guideline consisted of two parts. In the first part, participant characteristics, including biographical data as well as self-rated smartphone knowledge and frequency of use were assessed. The second part covered nine questions assessing needs and expectations of Rwandan patients with diabetes for a potential diabetes self-management smartphone application (Kir'App). It covered the following topics: willingness to use a health app, possible functions of the app and expected support in daily life or in the management of the disease. The interviews were done in two steps.

First, a discussion was initiated on the general topics presented above. In cases where respondents were hesitant with their answers or replied too broadly, questions designed to prompt more detailed answers were asked. These were questions pertaining to concrete functions of self-management systems derived from literature, for example, assistance with the maintenance of physical activity.²³

A professional translator was consulted for the translation of the interview guideline from English to Kinyarwanda. After translation, a pilot test involving five Rwandan diabetic patients was carried out to validate the guideline. It was adjusted according to their feedback. The final interview guideline is provided in the appendix section.

Sampling method

As there is no database of Rwandan diabetic patients owning smartphones in the RDA, convenience sampling was used to recruit study

participants. During a period of 2 months, a researcher attended the Rwanda diabetes clinic (located within the RDA) and invited every patient fulfilling the eligibility criteria to participate in the study.

Sample size

Redundancy within the answers hinted towards theoretical saturation when interviews with 21 participants had been conducted.

Interview setting and procedure

The face-to-face interviews were conducted at the RDA. After the self-introduction of the researcher, the purpose of the study was explained and a consent form was signed prior to the interview. The permission to record during the interview was obtained and when necessary, the researcher took some additional notes. The average duration of each interview was 1 h.

Ethical implications

Permission to conduct the study was obtained from the RDA and from the Institutional Review Board of the College of Medicine and Health Sciences of the University of Rwanda (no 021/CMHS/IRB). Participants were informed about their voluntary participation in the study and their right to withdraw their consent at any time. They were not compensated for their time with incentives. Participants signed the informed consent forms before the interviews were conducted. Anonymity and confidentiality were assured by coding participants' names and the storage of the transcript in a locked cabinet.

Analysis

Interview transcription, coding and reporting. Each interview was audio-recorded, transcribed and analysed, applying inductive category formation suggested within Mayring's method of qualitative content analysis.²² For the final codebook (see Appendix, Table A1), paraphrases from the transcript were used to describe each theme and subcategory.

First, transcription was performed by one researcher (CB). The authors (CB, LH and

PT) then familiarized themselves with the transcripts and afterwards, two of them (CB and PT) independently aimed to identify initial codes (themes). In a first iteration, underlying patterns and recurring schemes were identified within the answers to all guiding questions of the in-depth interviews. Those patterns formed the first broad categories. In a second iteration, some of these categories, appearing to cover different facets of a broader theme, were subsumed and thereby became subcategories.

After discussion and relabelling of both themes and subcategories, examples taken from the transcripts were added. This process was carried out independently by three authors (CB, LH and PT). Conflicting presumptions about themes and subcategories were discussed until agreement could be achieved or a third author settled the ties. No software was used for coding.

Reporting of study results is in line with the consolidated criteria for reporting qualitative research²⁴ as well as recommendations following the Standards for Reporting Qualitative Research.²⁵

Results

Participants suffered from either type 1 (female = 5, male = 6) and type 2 (female = 6, male = 4) diabetes and were aged between 18 and 69 years (mean age of 35.29 years). Three individuals refused to take part due to lack of time. No participant dropped out before the end of the interviews.

The characteristics of participating patients are summarized in Table 2. All participants ($n = 21$) reported that they would like to have a smartphone application supporting them in their diabetes management, either being strongly supportive ('it would be wonderful'; 'yes, it would be fantastic') or simply open minded ('Yes, if it can help me managing my disease, why not?'). A qualitative content analysis of the transcripts resulted in seven inductively formed themes. A summary of identified themes and subcategories is provided in Table 3. A more conclusive table summarizing the seven themes, their subcategories and one to four examples each can be found in the appendix section.

Table 2. Description of study participants.

Characteristic	<i>n</i>
Participants, <i>n</i>	21
Age	
Range	18–69
Mean	35, 29
SD	17, 71
Sex	
Male	10
Female	11
Marital status	
Single	11
Married	9
Widowed	1
Type of disease	
T1D	11
T2D	10
Diabetes duration, years (time since diagnosis)	
<1	1
1–5	7
6–10	8
11–15	3
16–20	2
Educational level	
Primary school	2
Secondary school	16
Higher education (university)	3
Work status	
Permanent job	7
Temporary	3
Student	5
Jobless	4
Retired	2

Table 2. (Continued)

Characteristic	<i>n</i>
Self-rated smartphone knowledge/skills	
Excellent	6
Very good	4
Good	8
Poor	3
Frequency of smartphone usage	
<Once a day	1
Once a day	1
>Once a day	19
SD, standard deviation; T1D, type 1 diabetes; T2D, type 2 diabetes.	

(1) Diabetes education and desired information provision

The theme refers to the provision of information, specialized education on diabetes in general and the coping with the disease.

(a) General information on diabetes, management and complications

Participants wished to receive information from the application that can help close their gaps on diabetes knowledge.

‘...the application should teach us the difference between type 1 and type 2 diabetes because most people of my age don’t know which type of diabetes they are living with. The application should also teach us more about the medications we take and why some people use tablets when others are using insulin although we all have type 2 diabetes? It should also teach us about side effects of medications...’ (P11)

(b) Medical parameters (e.g. blood pressure, blood glucose, body weight, etc.)

Some participants expressed their will to receive specialized knowledge on medical parameters of DM.

‘My blood glucose levels sometimes reach 400 mg/dl, I wish the application [would] tell me what caused it to raise that high and [...] teach me how I should lower it.’ (P4)

Table 3. Summary of recurrent themes and subcategories.

Theme	Subcategory
(1) Diabetes education and desired information provision	(a) General information on diabetes, its management and complications (b) Medical parameters (e.g. blood pressure, blood glucose, HbA1c, body weight, etc.) (c) Medical devices (d) Frequently asked questions by newly diagnosed patients (e) National/regional update and initiatives as well as services
(2) Lack of knowledge/awareness	(a) Lack of knowledge on living with diabetes (b) Prejudice and myths (social media knowledge) (c) Lack of knowledge on Web 2.0
(3) Crisis intervention	-
(4) Monitoring and reminder functions	(a) Blood glucose or sugar recording and trend visualisation (b) Reminder functions
(5) Nutrition and alcohol consumption	(a) Composition of a diabetes plate (b) Information on nonalcoholic beverage choices (c) Information on alcohol intake (d) Pleasure of eating
(6) Physical activity	(a) Type of exercise to do (b) Motivation for physical activity (c) Frequency and duration of physical activity
(7) Coping with burden of disease	(a) Emotional support (b) Social support
(8) App features	(a) Information delivery (b) Available languages
HbA1c, glycated haemoglobin.	

(c) Medical devices

Participants asked for support to monitor disease-specific parameters.

‘You know many diabetics like me don’t have glucose meters [...]. We take our medication without knowing our levels of blood sugar and we only come here to the clinic once [...] [a] month to check it or whenever we don’t feel okay.’ (P21)

(d) Frequently asked questions by newly diagnosed patients

Others underlined the special value of a target-group-specific repository of information for those being newly diagnosed with diabetes.

‘There are some people who are newly diagnosed with diabetes and who have a million questions

about it, [...] so the application should have a function [called] “frequently asked questions”.’ (P13)

(e) National/regional update and initiatives

Information on national or regional initiatives on diabetes care as well as local services (e.g. diabetes meetings) were asked for by the participants:

‘I wish the application to inform me about activities concerning diabetes that are taking place in Rwanda [...]. Activities [...] being organized for patients because now we don’t attend many due to lack of information.’ (P5)

(2) Lack of knowledge and awareness

This theme comprised characteristics of the individual end user, mainly knowledge gaps.

(a) Lack of knowledge on living with diabetes

Participants' responses indicated knowledge gaps concerning the everyday life with diabetes, especially concerning disease-related behaviour.

'I didn't know that someone could develop foot problems because of diabetes. Right now, I have athlete's foot and I've never thought that it could be linked to my diabetes [...]. I wish the application [would] teach us about foot problems in diabetes, [so] I can learn how to take care of them and [...] use it to teach other diabetics.' (P7)

(b) Prejudice and myths

Participants described false and misleading information being considered as true.

'The application can teach type 1 diabetics about how to live their love life with their diabetes. Most of them are ashamed to tell [...] their partners. Some people didn't go to school or don't know much about diabetes, they think that the person can contaminate them.' (P6)

(c) Lack of knowledge on Web 2.0

One participant referred to gaps in digital knowledge and limited trust in technology.

'I've seen some [diabetes self-management application] on Google Play but it requires a subscription; they are being connected to your bank account and they draw money from it. I was [...] scared of hackers, I abandoned the idea of subscription.' (P15)

(3) Crisis intervention

The third theme refers to information provision and immediate guidance in case of disease complications in order to prevent inadequate behaviour in stressful situations. No subcategory was found here.

'The application should teach us how to behave once you have hypos or highs because sometimes you become stressed which can raise your blood sugar levels more.' (P12)

(4) Monitoring and reminder function

Theme 4 refers to the continuous monitoring of disease-specific (medication, physical activity,

nutrition) parameters to be facilitated by the app. A second subcategory refers to reminder functions.

(a) Blood glucose or sugar recording and trend visualisation

The subcategory refers to digital monitoring and display of changes in diabetes parameters.

'Another thing I wish the application to offer would be a kind of diary to record the results of our blood glucose, A1c, blood pressure and body weight checking. A diary in which we can write possible mistakes, which may have caused the results of these health check-ups to be high or low compared to the normal values.' (P2)

(b) Reminder functions

Participants wish for automated reminders for appointments, physical activity, insulin use and food intake.

'The application can remind me to check my blood sugar and to take my insulin injection [...] and to exercise. It should also remind me of my doctor's appointments.' (P13)

(5) Nutrition and alcohol consumption

The theme refers to information provision on food and drink choices as well as alcohol intake. Four subcategories were found.

(a) Composition of a diabetic plate

Participants expressed a need for information on the kind of food being complementary with the disease.

'I wish the application to teach me what quantity of which food to put on my plate and the content [...] in terms of glucose and other nutrients.' (P3)

(b) Information on nonalcoholic beverage choices

This subcategory refers to diabetes-appropriate choices of beverages:

'[...] for example, I personally like soda very much and after I was diagnosed with diabetes I had to stop [drinking] it and whenever I used to pass by shops

[...] I felt my heart aching remembering that I couldn't drink [sodas] anymore. But is it true?' (P7)

(c) Information on alcohol intake

This subcategory refers to information on the acceptable kind and amount of alcohol, as well as possible interactions of insulin with alcohol.

'I wish to have a special page about beers diabetics can drink [...]. Or a page on how to still enjoy life besides having diabetes, because some people [...] [think] that beers and medications should never be mixed.' (P18)

(d) Pleasure of eating

This subcategory refers to dietary food intake and the consequences for pleasure while eating. For instance, participants report that they 'hate to always drink water' (P11), or refuse to go to parties because they cannot drink soda.

'Maybe the application can also give us tips on how to enjoy our food, because diabetics are known to always eat bitter.' (P11)

(6) Physical activity

The theme refers to information on the right kind and amount of exercise, as well as to motivational input for uptake and maintenance of physical activity.

(a) Kind of sport to do

The first subcategory refers to the kind of physical activity for people living with diabetes.

P17: 'The application can teach us about acrobatic games that are safe for diabetics. I used to be a player of acrobatic games but when I was diagnosed with diabetes, I stopped it and this frustrates me [...].'

(b) Motivation for physical activity

Participants report discouragement and lack of motivation for physical activity. They also ask for continuous support of behaviour change.

'The doctor told me to exercise at least 40mins a day, he said I have to walk quickly but I am not able to do so, that's why I don't exercise at all.' (P14)

(c) Frequency and duration of physical activity

This subcategory refers to information on the right amount of physical activity. Participants ask for tracking and performance-based recommendations.

'Then I decided to exercise twice a week after my job [...] but I don't know if it is enough.' (P20)

(7) Coping with burden of disease

This theme refers to emotionally supportive content and the ability to connect with others suffering from diabetes, easing the burden of disease.

(a) Emotional support

The subcategory refers to supportive content for emotionally distressing situations.

'I wish the application could give me advice about how to control my emotions (anger, bitterness, stress, sorrow, etc.).' (P2)

(b) Social support

The subcategory refers to social support when dealing with diabetes. Participants wish to be able to get in contact with other patients with diabetes, for example, in a forum to 'share goals and dreams' (P17).

'Can the application put me in contact with other people for example when I am feeling down so they can help me feel better (a kind of disease partner who is not necessarily sick but who knows diabetes well and who can help me)?' (P8)

(8) App features

Participants had difficulties imagining possible app functions. However, many referred to interactive information delivery options and the integration of different languages.

(a) Information delivery

This subcategory refers to content to be delivered *via* text, images, audios and videos.

'Videos are better, because you can see and understand what the doctor is explaining. At my age, reading may be tricky. I think that having both may be better.' (P5)

‘Sometimes we cannot even raise our hand when we are in a hypo, so the idea of having an audio would be to instruct us on what to do in case of a hypo crisis. Otherwise you can neither read nor watch a video.’ (P3)

(b) Available languages

This subcategory refers to desired languages to be supported by the app. Participants either wish to include local language, Kinyarwanda, or to also include English.

‘Kinyarwanda is better because even if you think you speak English, you may start reading and be confused with medical or scientific terminology, though you needed to understand everything well.’ (P7)

‘It would be great to have an option to change the language like for Facebook (the application should be both Kinyarwanda or in English for the choice of the use).’ (P3)

According to the qualitative analysis, the following functions were either mentioned by the participants (see above) or can be deduced from their mentioned needs and expectations:

- (1) Education provision tool using Kinyarwanda and English (including informational content on disease in general, medication and medication adherence, physical activity and nutrition, and their respective impact on coping with the disease and disease-related complications);
- (2) Monitoring system for disease-related parameters such as HbA1c as well as medication and nutrition intake and amount of physical activity;
- (3) Reminder functions based on monitored data, for example, for medication adherence and physical activity behaviour, as well as disease management, for example, appointments with physicians;
- (4) Crisis intervention function providing easy-to-access information in case of hyper- and hypoglycaemic events;
- (5) Social network function providing access to other patients and self-help groups, in order to offer social support as a coping mechanism for the burden of disease;

- (6) Combine written content with images and support it with both audio- and video-based information delivery.

Discussion

The assessment of expectations and needs of Rwandan patients with diabetes will be used to develop the first diabetes self-management smartphone application (Kir’App) for Rwandan patients with T2DM.

Eight main themes were identified: (a) diabetes education and desired information provision; (b) lack of diabetes knowledge and awareness; (c) need for information in crisis situations; (d) required monitoring and reminder functions; (e) information on nutrition and alcohol consumption; (f) information on physical activity; (g) coping with burden of disease; and (h) app features. Table 4 summarizes the study participants’ expectations that will guide the App development (functionalities and content) and table 5 shows the suggested future use of this study results.

Theory-grounded user-centred development

A recent systematic review concludes that mHealth studies for behaviour change in low- and middle-income countries are insufficiently based on behaviour-change theories.²⁶ Evidence on the HAPA shows that while all patients with T2DM should be presented with means to increase their self-efficacy, support during behaviour-change processes depends on the stage a person is at.²⁷ Accordingly, our results are discussed in reference to the single predictors and stages included in the HAPA.¹⁸

Risk perception, outcome expectancy and health literacy. Outcome expectancies cover most of the answers received in the semistructured interviews. As indicated in theory, outcome expectancies are said to increase the success rate of coping responses.²⁸ Outcome expectations and pretreatment self-efficacy predict greater intention to engage in health behaviours,²⁹ as they allow for carrying out plans.³⁰ Among the expectations towards the potential smartphone application is a special feature for the provision of education on diabetes in general and coping strategies with disease-related complications. Participants also expect the application to provide response to their lack of

Table 4. Study participants' expectations guiding the app development: functionalities and content.

Study participants' expectations guiding the app development: Functionalities and content	
(1)	Information, specialized education on diabetes and skills for coping with the disease
(2)	Knowledge about diabetes burdens in everyday life and crisis situations
(3)	Information on food, drink choices and alcohol intake
(4)	Right type, amount and motivational input for physical activity
(5)	Monitoring and reminder functions for diabetes parameters (health check-ups), doctor's appointments and medication taking
(6)	Emotionally supportive content and the ability to connect with other people living with diabetes
(7)	Bilingual support using both Kinyarwanda and English
(8)	Information delivery combining written content, images, audio and videos according to users' preferences

Table 5. Future use of this study's results.

Future use of this study's results
The findings of this study will:
(1) be used to develop the first diabetes self-management smartphone application (Kir'App) for Rwandan patients with T2DM;
(2) inform the Ministry of Health of Rwanda as well as the Rwanda Diabetes Association about the needs of Rwandan diabetic patients in terms of diabetes education and management;
(3) raise awareness among diabetic patients' associations, social movements, and decision makers about the needs of Rwandan diabetic patients, providing help for the necessary advocacy;
(4) open a way for Rwandan diabetic patients to verbalize their needs and facilitate development of their healthcare.
T2DM, type 2 diabetes mellitus.

knowledge and awareness about coping with the diabetes burden in everyday life, which is often impaired by common diabetes myths and rumours. This is noteworthy as disease-related literacy is an important predictor for risk perception.³¹ Furthermore, patients with knowledge deficits or low health literacy are expected to benefit most from mHealth interventions.³²

Health literacy is the basis for a successful self-management, as also stated by Saha and colleagues.³³ This is supported by guidance published by the American Diabetes Association, the American Association of Diabetes Educators, and the Academy of Nutrition and Dietetics.³⁴ A survey of people in Rwanda revealed that general knowledge and perceptions of T2DM was low, highlighting the need for education campaigns.⁵ Therefore, adequate education corresponding to the individuals'

level of health literacy is needed, even more so as increased health literacy has been shown to improve self-efficacy and therefore coping behaviour in an Iranian sample of diabetes patients.³⁵

Diabetes self-management, monitoring and crisis intervention. Study participants also wished to have a diabetes self-management application with the capacity to assist them with crisis intervention. By providing information in case of disease complications, such as episodes of low and high blood sugar values, patients can be empowered to prevent wrong behaviour in stressful situations. As for community-based strategies, Gallé and colleagues found proof for benefits from improved diabetes self-management on the management of hypoglycaemic crisis.³⁶ For diabetic patients enrolled in a telehealth programme, Chen and colleagues found improvement in problem solving through a

teleconsultant service.³⁷ Overall, crisis intervention may refer to recovery self-efficacy, as well as action control predictors of the HAPA. It is well known that during the phase of intention and action planning, coping strategies for potential setbacks need to be included.¹⁸ However, evidence is missing for what conditions are required to maintain a new behaviour and to prevent relapse, as well as how to re-establish the new behaviour after relapse.³⁸

An automated monitoring system that facilitates continuous monitoring of disease parameters, such as blood glucose tracking, was among the most cited potential features in the present study. In a cross-sectional study by Borges and colleagues, 111 participants were in favour of using continuous glucose monitoring provided it was easy to use and did not produce information overload.³⁹ Both preconditions support the importance of early-user integration in the design process of the Kir'App. Also, feedback and monitoring are among the most frequently applied behaviour-change techniques in theories applied to mHealth interventions.²⁶

Along with a monitoring of disease parameters, patients expressed the need for knowledge on behaviours related to everyday life with diabetes, such as foot care, for example. For rural diabetic patients in Montana, Ciemins and colleagues found higher adherence rates for regular foot care when applying a telehealth self-management programme.⁴⁰ Such cues to action are important in behaviour-change theories as well,⁴¹ which is why Schwarzer subsumes them under barriers and resources in the HAPA.¹⁸

Participants wish for an application feature that offers specific information on food, nonalcoholic drink choices and alcohol intake to facilitate their daily diabetes-related nutritional choices. The potential of telehealth applications to improve dietary behaviour are, again, supported by Chen *et al.*,³⁷ as well as by a randomized controlled trial carried out by Fernandes *et al.*⁴² Again, the presented findings support the link between health literacy and self-efficacy. Within theory, task self-efficacy describes the extent to which an individual is convinced to be able to successfully take up a particular behaviour.⁴³

Enhanced motivation through emotional and social support. In order to comply with diabetes-specific physical activity recommendations, participants expected the application to give them information

on the right type, amount of and motivational input for physical activity. This strongly relates to maintenance and recovery self-efficacy during the action planning and action control.¹⁸ Dobson and colleagues found improved patient adherence to diabetes and health behaviours, as well as better HbA1c values when using motivational text messages to support DSM.⁴⁴ In the present study, patients expressed their loneliness and they found that it could be addressed by an application feature that offers emotionally supportive content and the ability to connect with other people living with diabetes. This is an especially important contribution, given that Koetsenruijter and colleagues found a strong association between social support by emotional networks (family and friends) and successful diabetes self-management.⁴⁵

Our findings are supported by the qualitative results of Desveaux and colleagues calling for a balanced consideration of self-efficacy, competing priorities, previous behaviour change, and beliefs about Web-based solutions.⁴⁶

Implications

In a systematic review comparing 55 healthcare systems of sub-Saharan African countries in the management of diabetes, Rwanda was assessed among countries with health partnerships and systematic care that facilitate patient access to diabetes information, care and adherence to treatment.⁴⁷ Decentralization, focus on community health and insurance scheme are traditionally seen as strengths for the Rwandan health system.⁴⁸ These aspects may be a support to test, evaluate and roll out the innovative self-management application developed in the Kir'App Rwanda Diabetes study project.

The expectations and needs of Rwandan diabetic patients were collected using a strongly user-centred study design. Coresearch, defined as research in partnership with older people, is said to enrich results derived from research based on older peoples' interpretations of their own lives.⁴⁹ This method is said to foster an improved understanding of heterogeneous target populations and presents a promising approach for partnerships at the community level.⁵⁰ In addition to the fact that there is no current diabetes app available for Rwandan diabetes patients, qualitative findings from patients in Canada describe how currently available apps inadequately address the needs of patients.⁵¹

Limitations

Qualitative methods such as focus groups or in-depth interviews are commonly used for user-centred design processes in the domain of health technologies.⁵² However, the study design, using a semistructured interview guide for qualitative research, has well-known limitations. Although a pretest was conducted, back-and-forth translation from English to Kinyarwanda may have led to misinterpretations or loss of information. Additionally, analysis was theme based and interpretative. Therefore, the individual backgrounds of the researchers may have had an impact on the final results. In order to address this risk of confirmation bias, analysis of data was independently carried out by two of the authors and coding was later supervised by another.²²

As databases for patients with diabetes are missing, convenience sampling in a professional setting, the RDA, was used. Using this method, patients not attending this association at all were missed, or if not attending on a regular basis, were less likely to be included. This especially applies to patients living in rural communities, having limited health literacy (indicated by not visiting the RDA on a regular basis) or those being unaware of their conditions. Although attempts were made to recruit diverse patients, those that refused to take part may have provided additional insights. Therefore, participants of the interviews may be generally more responsive to health services and studies.

Data were collected from 21 individuals, derived from a highly heterogeneous study population (Table 2) in terms of age, sex, time since diagnosis and working status, and cannot be generalized to a larger population.

The study aimed to assess needs and expectations of Rwandan diabetic patients as potential users of the first Rwandan diabetes self-management app. Though specific functions would have been a valuable help to design this first app of its kind in Rwanda, participants may have been overstrained to imagine possible functions, as they never used a comparable app or device before.

Conclusions

The outcomes of this study have provided recommendations that are currently being used to

develop the first Rwandan diabetes self-management smartphone application, Kir'App. Kir'App is expected to strengthen the empowerment of Rwandan diabetic patients using smartphone applications in their diabetes self-management capacity. The expectations and needs of patients with diabetes is the strong focus on functions and design of a future smartphone application and is in line with the present call for user-centred development of health interventions. The qualitative insights provide a prototype of the first diabetes self-management smartphone application (Kir'App). The respondents highlight the importance of combining knowledge-oriented components with monitoring functions. They call for connecting their own living with diabetes with both social support derived from peers, as well as regional/national initiatives.

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Author Contributions

CK and PS contributed to the initial conceptual planning of the project and design of questionnaire. CK researched data. CK, PT and LH contributed to the analysis and interpretation of data. PT and LH contributed to the discussion, reviewed and edited the manuscript. CK, PT and LH wrote the manuscript. PS approved the version to be published.

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Conflict of interest statement

The authors declare that there is no conflict of interest.

Supplemental material

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Appendix

Table A1. Summary of recurrent themes and subcategories with examples.

Theme	Subcategory	Examples
(1) Education and desired information provision The theme refers to the provision of information, specialized education on diabetes in general and coping with the disease	(a) General information on diabetes, management and complications This subcategory refers to information that should be provided by the app in order to close general knowledge gaps on disease characteristics, management (through medication and behaviour change) and complications	<p>P5: 'I wish the application to help me to master in the care of my disease by giving me more information about diabetes and helping me to change behaviour in order to care after my disease.'</p> <p>P6: 'I need to know much about insulin. I think that even all those tablets we take are also insulin in different forms, but I would like to know if insulin injections taken on a long-term may cause damages in the human body. I know it's the only medication we must take, but are there precautions we should follow or respect while taking injections or other tablets? What are the short- or long-term complications which may occur? Right now, I have neuropathy; can't it be due to those insulin injections I am taking? There is also another problem we often discuss with other diabetics without finding answers; why are our bodies not producing insulin? I heard that it is because of malfunction of the pancreas (though I am not sure if that information is correct) but if it is, why can't our pancreas be treated and healed?'</p> <p>P11: 'First of all, the application should teach us the difference between type 1 and type 2 diabetes because most of people of my age don't know which type of diabetes they are living with. The application should also teach us more about the medications we take and why some people use tablets when others are using insulin although we all have type 2 diabetes? It should also teach us about side effects of medications, you know taking the same medicine for 10-20 years, I guess it causes some harm to the body. Because I know someone who was diagnosed with diabetes after me and the Dr prescribed her immediately insulin. He told her that tablets are not good because they immediately go into the blood, and that insulin was better. I was really confused.'</p>
	(b) Medical parameters (e.g. blood pressure, blood glucose, HbA1c, weight, etc.) This subcategory refers to specialized knowledge on parameters of diabetes symptoms and progression	<p>P18: 'The application should have a special page about all the tests and health exams we need to do as diabetics and mention when and why we should do them. Imagine that I used to think that through the HbA1c test; both my eyes and kidneys were also screened.'</p> <p>P4: 'My blood glucose levels sometimes reach 400 mg/dl, I wish the application to tell me what caused it to raise that high and very importantly to teach me how I should lower it. Can it also have the capacity to show me my blood glucose levels?'</p> <p>P3: 'The application should teach me what are the normal values of HbA1c, the poor values to avoid and how to keep it in normal ranges.'</p>
(c) Devices This subcategory refers to information provision on new medical devices to monitor diabetes parameters	(c) Devices This subcategory refers to information provision on new medical devices to monitor diabetes parameters	<p>P5: 'I wish the application to inform me about newly discovered devices being available on the market that may help in diabetes care. You see, we use different glucose meters. I would like the application to tell us for example whenever there are some other available new glucose meters that can be more efficient, and maybe less expensive. Or maybe some other devices we don't know so far that can be used in diabetes care.'</p> <p>P16: 'In case I want to check my blood glucose levels, I wish an application that can show me my blood glucose levels by using my finger print only without being obliged to prick my finger to get a blood drop.'</p> <p>P21: 'You know many diabetics like me don't have glucose meters or we buy them and don't repair them once they have defects. We take our medication without knowing our levels of blood sugar and we only come here to the clinic once in month to check it or whenever we don't feel okay. Is that good? The application should teach us more about that.'</p>
	(d) Frequently asked questions by newly diagnosed patients This subcategory refers to a repository of information for those newly diagnosed with diabetes	<p>P13: 'There are some people who are newly diagnosed with diabetes and who have a million questions about it, even we ourselves still have many unanswered questions about it; so the application should have a function of frequently asked questions' with their answers for a rapid consultation in case of need.'</p> <p>P14: 'it's been only 1 year since I was diagnosed with diabetes and I have to confess that I have many unanswered questions about it. Maybe the application can make a kind of summary about everything a new diabetic has to know so by reading it we can have an overview of our disease.'</p>

Table A1. (Continued)

Theme	Subcategory	Examples
<p>(2) Lack of knowledge/awareness This theme comprised characteristics of the individual end user, mainly knowledge gaps</p>	<p>(a) Lack of knowledge on living with diabetes This subcategory refers to knowledge gaps concerning the everyday life with diabetes, especially concerning disease-related behaviour</p>	<p>P5: 'I wish the application to inform me about activities concerning diabetes that are taking place in Rwanda and that we can attend. And those ones taking place outside Rwanda even if I may not be able to attend them. Activities like meetings, workshops, conferences and sensitization activities about diabetes that are being organized for patients because now we don't attend many due to lack of information.' P1: 'Another idea that would be great would be an application that can indicate us possible pharmacies (in Kigali for example) where someone can buy insulin and syringes. Because someone can come from another province (for example, western) to Kigali and not knowing where to buy products he really needs for his diabetes care.'</p>
	<p>(b) Prejudice and myths (social media knowledge) This subcategory refers to false information being considered true</p>	<p>P16: 'Sometimes there are some topics the Dr teaches me when I come to my regular appointments but I don't understand them well and I ask for more explanations to my mother and then we google them (for example, about the control of blood glucose levels, food and so on) and try to get answers. So, I think that if we had the application, it would help me to learn more.' P7: 'What is the problem with feet in diabetes? I didn't know that someone could develop foot problems because of diabetes. Right now, I have athlete's foot and I've never thought that it could be linked to my diabetes but now that you mention it, I will go back to the doctor and ask for a treatment. Now, I wish the application to teach us about foot problems in diabetes, I can learn how to take care of them and I can use it to teach other diabetics like me who may be unaware of that information.' P10: 'The application should teach us about type 1 diabetes and pregnancy. We are not sure if as type 1 diabetics we can have children, and if we get pregnant, can we keep taking insulin?' P4: 'The application should teach us about diabetes care in our everyday life, for example I smoke, I would like to know if it is good or bad for a diabetic.' P4: 'The application should also tell us about all possible diabetes myths (for example some people say that when you grow up, your diabetes shift from type 1 diabetes to type 2), in order to protect us against them since there are many outside here and sometimes the person telling it looks smart and you are tempted to believe him.' P6: 'The application can teach type 1 diabetics about how to live their love life with their diabetes. Most of them are ashamed to tell it to their partners. Because there are many known cases where the partner broke with the person after knowing that s/he had diabetes. Some people didn't go to school or don't know much about diabetes, they think that the person can contaminate them, others think that once they get married they can die or develop complications and that their lives would be worse or the healthcare would cost them much.' P3: 'The application should teach us about diabetes myths and how to behave as young diabetics. How to behave once a type 1 diabetic gets married, how to behave at your work or in your family and how to deal with alcoholism, drug abuse, adultery, fighting, etc.'</p>
<p>(c) Lack of knowledge on Web 2.0 This subcategory refers to gaps in digital knowledge and trust in technology</p>	<p>P15: 'I've seen some [application] on Google Play but it requires a subscription; they are being connected to your bank account and they draw money from it. I was not sure of them, scared of hackers, I abandoned the idea of subscription.'</p>	

(Continued)

Table A1. (Continued)

Theme	Subcategory	Examples
<p>(3) Crisis intervention This theme refers to information provision in case of disease complications in order to prevent panicky behaviour</p>		<p>P9: 'When I am in class and start feeling bad, I wish to be able to check the application and get to know if it is a hypo or a high episode I am going through.'</p> <p>P12: 'The application should teach us how to behave once you have hypos or highs because sometimes you become stressed which can raise your blood sugar levels more. It (the application) can also be my logbook where I can write my blood sugar levels and my doses of insulin of every day.'</p> <p>P9: 'I wish the application to teach me tips about food and drinks or anything else that can help me to keep myself from hypos and highs. I hate to have hypos because after the hypo episode, everyone knows that I have diabetes and I hate people to know that I have diabetes.'</p> <p>P14: 'Right now, I have a flu and whenever I have it, I lose appetite and can't eat anything which causes me to have high blood sugar levels that I treat with insulin and then I have low blood sugar levels. So the application should teach us about the management of diabetes in case we have other diseases like flu, malaria, that can interfere with our appetite and cause changes in our blood glucose levels. Those diseases have even some symptoms similar to hypo/highs and you can't guess if you have a hypo or high.'</p>
<p>(4) Monitoring and reminder functions This theme refers to monitoring and reminder functions; the app should incorporate disease-relevant parameters, including medication, physical activity and nutrition</p>	<p>(a) BG/BS recording and trend visualization This subcategory refers to monitoring and display of changes in diabetes parameters to be done via the app</p>	<p>P2: 'Another thing I wish the application to offer would be a kind of diary to record the results of our blood glucose, A1c, blood pressure and body weight checking. A diary on which we can write possible mistakes, which may have caused the results of these health check-ups to be high or low compared to the normal values. That diary would help us to do a kind of self-evaluation. Based on knowing the mistakes we did, next time we may take measures for correcting them referring ourselves to our diary.'</p> <p>P3: 'The application should [...] help me to keep all my previous health records in order to show them to the Dr so he can do a follow up of my progress.'</p> <p>P4: 'I usually use a diary to record my blood glucose results but when I have a fieldwork or when I go unexpectedly for a job mission I forget the diary but I never forget my smartphone, so it would be good to have a kind of electronic diary.'</p> <p>P13: 'Sometimes when you are not at home, it's challenging to measure your blood sugar in order to take your insulin. I know that there are applications that show people what is their heart beat and pulse. I wish we could also have an application that shows us our regular blood glucose levels without being obliged to use glucose meter and needles.'</p> <p>P15: 'I usually work much and use much energy since I am an IT technician, so at 11-12 a.m. when I take a break, I would like the application to show me the variation of my blood glucose levels. Then other times when I am not using much energy like when I am repairing a computer, the application can also help me to track the variation of my blood glucose levels. This way I can get to know how my blood sugar levels change depending on my daily activities and know how to adjust to it.'</p> <p>P16: 'I wish the application to track my physical activity, show me my heart beat and tell me when I have done enough exercise.'</p>
<p>(b) Reminder functions This subcategory refers to automated reminders for physical activity, insulin use and food intake to be provided by the app</p>	<p>P2: 'It could also remind me when to do exercise during the week days because I forget it most of the time and my mother has to remind me to do it with her only on Fridays after work, though I know I have to do it at least three times a day. So if I had an application in which I could set days of doing sport for example on Mondays, Wednesdays and Fridays, I think it would be great and help me more in controlling my blood sugar.'</p> <p>P3: 'The application should first remind me of the Dr's appointment.'</p> <p>P13: 'The application can remind me to check my blood sugar and to take my insulin injection at the same hour of every day. It should ring also at the same hour of every day to remind me to do exercise because I can be busy and forget to do it so the application should remind us that even when busy, we should find 30 min for exercise. It should also remind me of doctor's appointments.'</p> <p>P14: 'The application should remind me when it's time to check my blood sugar and the estimated time my insulin medication will run out so I can buy another one on time because sometimes I just forget to buy it and I experience shortage when I am not ready to buy another one (not having money for example) and I can spend a day or two without taking it which is bad.'</p>	

Table A1. (Continued)

Theme	Subcategory	Examples
<p>(5) Nutrition and alcohol consumption This theme refers to information provision on food and drink choices, as well as alcohol intake, to be delivered by the app</p>	<p>(a) Composition of a diabetic plate This subcategory refers to information provision on what kind of food is complementary with the disease</p>	<p>P3: The application should teach us about types of food that don't contain much glucose. Sometimes I may take much quantity of rice and little quantity of beans whereas I should do the opposite. I wish the application to teach me what quantity of which food to put on my plate and the content of each possible food in terms of glucose and other nutrients. P6: For the food, the application should show us which one is allowed. They usually teach us about how a diabetic plate must be prepared (how to divide it in 4 parts; with one side for banana, another one for beans, another one for vegetables and fruits) but we most of the time forget it, so the application should give us a list of different categories of food we can eat depending on the availability of food we have here in Rwanda. P5: We need to have an application that can teach us more about diabetics' diet. Having a list of common food with their glucose content. You hear some people saying; potatoes contain much glucose, another one; rice is worse, another one; forget sweet potatoes for the good. That's the main problem I experienced when I was diagnosed with diabetes; suddenly I was not allowed to eat anything, I lost much weight and I was most of the times nearly fainting because of hunger. [...] And when I talk with other diabetics; that is the very first main challenge they say that they meet.</p>
	<p>(b) Information on nonalcoholic beverage choices This subcategory refers to information about diabetes-appropriate choice of beverages the app should provide</p>	<p>P2: Sometimes it is really hard for example in case of a party taking place at home when others are drinking soda or juice and you wonder what to do; drinking them or mix them with water and do like you are enjoying the drinks like others? So most of the time I check my blood sugar and drink a soda. I also heard that drinking water reduces blood sugar, so sometimes when I have high blood sugar (in case of sorrow, stress, etc.), although I have taken my insulin shot, I wonder if I could drink water and reduce my blood glucose instead of taking another injection. P7: [...] for example, I personally like soda very much and after I was diagnosed with diabetes I had to stop taking it and whenever I used to pass by shops with sodas in fridges I felt my heart aching remembering that I couldn't drink it anymore. But is it true? Can't we take some food or drink we like maybe once in a while and keep enjoying our life? P8: The application can teach us about milk, because I love milk; I can take 1 litre of curdled milk a day. But the application should also tell us something about pasteurized milk. There are some people like me who can even take 3 litres of milk a day but we don't know if it can cause problems or if it can interfere with the pills or insulin we take.</p>
	<p>(c) Information on alcohol intake This subcategory refers to information about the acceptable kind and amount of alcohol the app should provide</p>	<p>P13: [...] some people like drinking alcohol, the application should maybe direct us how much quantity they should drink, maybe a half bottle. For example, type 1 diabetics feel young and strong. Some drink alcohol and when you get drunk, you can easily fall down and get injured and some people aren't even aware of their injury when they are high, coming home, they sleep and the next day they deal with their hangover and the person may have to go to a hospital when the wound is infected and maybe get amputated in the future. P18: I wish to have a special page about beers diabetics can drink and have fun with friends and still enjoy life. Or a page on how to still enjoy life besides having diabetes, because some people choose not to take insulin injection or pills when they are going to take beers, thinking that beers and medications should never be mixed. Other people cannot stop taking beers, should they die? Like me, I can take 5 bottles of Skol [malt] when I am with my friends, I know it's bad but what should I do, I like it. P5: You hear also some men [diabetics] saying that the doctor said they can take Skol and you wonder which kind doctor advises his patients to take alcohol. They forget that even if alcoholic beverages are bitter but still have amount of carbohydrates which increase blood sugar levels.</p>
	<p>(d) Pleasure of eating This subcategory refers to the perceived cognitive effort of dietary food intake and the consequences for enjoyment when eating</p>	<p>P21: Isn't there any way our everyday life could be improved? Why do we have to eat only bitter? Aren't there new researches about that? The application should inform us about that. P11: Maybe the application can also give us tips on how to enjoy our food, because diabetics are known to always eat bitter. And when you are diagnosed at an old age, it is really hard to stop with your life time habits in terms of food. P4: Sometimes I refuse to go to parties because I don't drink alcohol and when I think I can't take soda either I refuse to go as I hate to always drink water. Can the application teach me what else I might do to enjoy parties like others? P19: I stopped to eat whatever contains sugar even fruits; I can't eat banana or pineapple, I only use the diabetic sweeteners. If the application could teach me which fruits are good and at which quantity I can eat them, it would be great. P20: I stopped to eat quite everything because people and doctors were telling me to do so. I used to like rice, I can't eat it anymore. That is cite one example; they tell us to eat pumpkins only. But can someone survive with that one kind of food? The application should tell us about all categories of food we are allowed to take.</p>

(Continued)

Table A1. (Continued)

Theme	Subcategory	Examples
<p>(6) Physical activity This theme refers to information provision on the right kind and amount of exercise as well as motivational input for physical activity to be delivered by the app</p>	<p>(a) Type of sport This subcategory refers to the kind of physical activity one should pursue when having diabetes</p>	<p>P11: 'Which physical activity fits old people like me?' P17: 'The application can teach us about acrobatic games that are safe for diabetics. I used to be a player of acrobatic games but when I was diagnosed with diabetes, I stopped it and this frustrates me because I used to like it much.' P16: 'The application should show us which equipment diabetics are allowed to use in the fitness studio and the time they should spend using them. Which one is better to use in order to make us healthier? And of course the ones that might be dangerous for us and what we don't really need.'</p>
	<p>(b) Motivation for physical activity This subcategory refers to motivational input the app should deliver to the end user</p>	<p>P11: 'I am retired and have time for exercise but I lack motivation and become discouraged whenever I imagine what people would think if they see an old woman running on the street. I don't have people who motivate me. Sometimes I exercise at home and walk many rounds during 30 min but it's not every day. I wish the application to give us motivation.' P14: 'The doctor told me to exercise at least 40 min a day, he said I have to walk quickly but I am not able to do so, that's why I don't exercise at all. Maybe the application could teach us more flexible ways of exercising so we can be motivated to do it instead of abandoning it completely.' P20: 'It is really hard to exercise every day. You know it is really difficult to wake up every morning for exercise when you are 50-years old and you've never done it before. I tried and failed.'</p>
	<p>(c) Frequency and duration of physical activity This subcategory refers to information on the right amount of physical activity one should pursue to be delivered by the app</p>	<p>P16: 'I wish the application to track my physical activity, show me my heart beat and tell me when I have done enough exercise.' P20: 'Then I decide to exercise twice a week after my job. I do it for like 1 h. But I don't know if it is enough. The application should teach us about what is better to do.' P3: 'Sometimes we see other people exercising for example for 2h and we follow them. I wish the application to teach me what, as a diabetic, I am supposed to do before I am working out. The application should [...] teach [...] the right duration of physical exercise because for example I can go for a football game which lasts for 90 min and may encounter some problems.'</p>
<p>(7) Coping with burden of disease This theme refers to functionalities of the app which allow for better coping with diabetes through emotionally supportive content and the ability to connect with others suffering from diabetes</p>	<p>(a) Emotional support This subcategory refers to supportive content for emotional distressing situations due to the disease, which should be provided by the app</p>	<p>P1: 'Receiving some recommendations and advice from the application would be very helpful. For example, some advice about behaviours to adapt in different situations, like now I am about to start university. The application can give me some advice for example about how to cope with the stress caused by the new environment; how to keep on respecting my schedule of taking my insulin injections on time and so on.' P2: 'I wish the application could give me advice about how to control my emotions (anger, bitterness, stress, sorrow, etc). Since I heard that most of them cause the blood sugar to raise. It should give me some advice for example to listen to music and sleep whenever I feel unhappy and so on.' P3: 'The application should teach us how to behave as a diabetic; for example, as a young girl how to avoid alcoholism, drug and adultery which hinder my health and my blood sugar and worsen my diabetes. How to behave with my friends who don't have diabetes or other people or my family in general. Because there are some diabetics who live isolated, always angry or depressed and don't live well with others. How to behave at home; some don't live relaxed at home with their siblings (or are never happy for/with them) or are jealous of them because they are sick and not them. Some refuse to do any chore at home pretending that they are sick and spend time in bed while their siblings are doing everything. They may not play with them as a kid, not eat the same food like them and use their disease to be capricious or disturb the family atmosphere because of their diabetes.' P6: 'You can teach young people with type 1 diabetes about having hope in life. As we know that diabetes can be hereditary, some of us just stack on that idea and live hopeless thinking that they can never get married because they don't want their children to live the same hell they are living. Whenever I meet some, I try to convince them of the opposite; showing them how a young type 1 like me became a happy married woman with one kid without diabetes and pregnant with a second one and that I live a happy life, but it is hard to convince them. So if the application could teach us about that aspect, it would be very great.'</p>

Table A1. (Continued)

Theme	Subcategory	Examples
<p>(b) Social support This subcategory refers to social support when dealing with diabetes, which should be incorporated into the functionalities of the app</p>	<p>(a) Information delivery This subcategory refers to content to be delivered via text, images, audios and videos</p>	<p>P11: 'I told you that I sometimes become discouraged to go for exercise alone because in my neighbourhood there are only young people busy with their jobs. There is no other people with diabetes or hypertension to motivate me; if the application could help us knowing each other; we can even organize meetings and share our experiences; our hope to live. Like I was diagnosed at an old age but there are young mothers and fathers who need to be encouraged to fight and keep living and see their children growing up.'</p> <p>P12: 'The application can give us a function to teach us to accept our disease, to strengthen our self-confidence and help us to keep strong. To remind us that despite of our disease we will become adults like others. Because sometimes when we meet with discouraging people, we feel down. I don't know if we can have a forum on the application where we can meet as diabetics but also invite other people so we can explain them about diabetes. Telling them that despite of our diabetes, we are also human beings. To tell them, that they should not despise us because we didn't choose to suffer from it.'</p> <p>P8: 'Can the application put me in contact with other people for example when I am feeling down so they can help me feel better (a kind of disease partner not necessary sick but who knows diabetes well and who can help me)?'</p> <p>P17: 'There should also be a function like a forum where we can share our contacts, address, picture and our goal or dream in life so we can get to know each other as diabetics. See, today I met a guy here at the clinic I use to meet in my neighbourhood without knowing he was also a type 1 diabetic. If we knew we had the same condition, I am sure we could have helped each other much.'</p> <p>P18: 'I think the app can connect us because like me I don't know many other diabetics and I think its causes me to be less informed.'</p>
<p>(8) App features Although participants had difficulties imagining possible app functions, this theme refers to interactive information delivery options and the integration of different languages</p>	<p>(a) Information delivery This subcategory refers to content to be delivered via text, images, audios and videos</p> <p>(b) Available languages This subcategory refers to desired languages to be supported by the app. Participants either wish to include local language, Kinyarwanda, or to also include English</p>	<p>P5: 'Videos are better, because you can see and understand what the doctor is explaining. At my age, reading may be tricky. I think that having both may be better.'</p> <p>P3: 'Sometimes we cannot even raise our hand when we are in a hypo, so the idea of having an audio would be to instruct us on what to do in case of a hypo crisis. Otherwise you can neither read nor watch a video.'</p> <p>P1: 'Having an audio to tell you what to do in case of hypos and high sugars would be great since you cannot read or watch a video properly when you are experiencing one of those crises but you can listen to an audio and follow instructions [...] The idea of using images to show you how to take care of my foot would also good.'</p> <p>P7: 'Videos are also better because when reading, you can get confused, but when you see the person speaking, you understand well.'</p> <p>P11: 'Videos are better because sometimes you can read and don't understand meaning and the context.'</p> <p>P7: 'Kinyarwanda is better because even if you think you speak English, you may start reading and be confused with medical or scientific terminology, though you needed to understand everything well.'</p> <p>P3: 'It would be great to have an option to change the language like for Facebook (the application should be both Kinyarwanda or in English for the choice of the use).'</p> <p>P1: 'Having an option of either using it in Kinyarwanda, French or in English would be better.'</p> <p>P5: 'It's better to have the application in Kinyarwanda because many people, even if they went to school, they may not understand medical terms if they are in English.'</p> <p>P13: 'Some Rwandans don't know Kinyarwanda well, it will be better to put the application in both Kinyarwanda and English.'</p>
<p>BG, blood glucose; BS, blood sugar; HbA1c, glycosylated haemoglobin; IT, information technology.</p>		