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RESEARCH ARTICLE (ORIGINAL)

Mobile applications to support type 2 diabetes self-management: patient experiences, needs, and preferences

Aplicações móveis de apoio à autogestão da diabetes tipo 2: experiências, necessidades e preferências do cliente

Aplicaciones móviles de apoyo a la autogestión de la diabetes tipo 2: experiencias, necesidades y preferencias del cliente

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Abstract
Background: Mobile applications can be useful in diabetes self-management. Knowing the needs and preferences of users is essential for these tools to provide effective support in this process.
Objective: To learn about the experiences, identify needs, and explore the preferences of people with type 2 diabetes *mellitus* regarding mobile applications to support diabetes self-management.
Methodology: Qualitative descriptive study with 12 participants selected using the snowball sampling technique. Data was collected through semi-structured interviews and analyzed using the content analysis technique.
Results: Six categories emerged from the analysis: functions and technical characteristics, informative content, self-determination, emotional management, health professional, and facilitating factors. The results suggest poor digital skills, need for access to information, and preference for multifunctional and interactive applications.
Conclusion: Despite the limited use of health-related apps, people are interested and realize the benefit of using these tools to manage their diabetes.

Keywords: diabetes mellitus, type 2; mobile applications; self-management; patient preference

Resumo
Enquadramento: As aplicações móveis podem ser úteis para a autogestão da diabetes. Conhecer as necessidades e preferências dos utilizadores é fundamental para que estas ferramentas sejam um suporte efetivo neste processo.
Objetivos: Conhecer as experiências, identificar as necessidades e explorar as preferências de pessoas com diabetes *mellitus* tipo 2 relativamente a aplicações móveis de apoio à autogestão da doença e regime terapêutico.
Metodologia: Estudo descritivo, de natureza qualitativa, com 12 participantes recrutados por técnica amostral de bola de neve. Dados recolhidos por entrevistas semiestruturadas e analisados pela técnica de análise de conteúdo.
Resultados: Emergiram seis categorias (funções e características técnicas, conteúdos de informação, autodeterminação, gestão de emoções, profissional de saúde e fatores facilitadores). Os dados sugerem baixas competências digitais, necessidade de acesso à informação e a preferência por aplicações multifuncionais e interativas.
Conclusão: Apesar da utilização parca de aplicações relacionadas com a saúde, as pessoas assumem interesse e percecionam o benefício de utilizar estas ferramentas para gerir a sua diabetes.

Palavras-chave: diabetes mellitus tipo 2; aplicativos móveis; autogestão; preferência do paciente

Resumen
Marco contextual: Las aplicaciones móviles pueden ser útiles para el autocontrol de la diabetes. Conocer las necesidades y preferencias de los usuarios es esencial para que estas herramientas sean un apoyo eficaz en este proceso.
Objetivos: Conocer las experiencias, identificar las necesidades y explotar las preferencias de personas con diabetes *mellitus* tipo 2 relacionadas con las aplicaciones móviles de apoyo a la autogestión de la enfermedad y al régimen terapéutico.
Metodología: Estudio descriptivo, de naturaleza cualitativa, con 12 participantes seleccionados por la técnica de muestra de bola de nieve. Datos recogidos por entrevistas semiestructuradas y analizados por la técnica de análisis de contenido.
Resultados: Surgieron seis categorías (funciones y características técnicas, contenidos de información, autodeterminación, gestión de emociones, profesional sanitario y factores facilitadores). Los datos sugieren bajas competencias digitales, necesidad de acceso a la información y preferencia por aplicaciones multifuncionales e interactivas.
Conclusión: A pesar de la escasa utilización de aplicaciones relacionadas con la salud, las personas muestran interés y perciben el beneficio de utilizar estas herramientas para gestionar su diabetes.

Palabras clave: diabetes *mellitus* tipo 2; aplicaciones móviles; autogestión; preferencia del paciente

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Introduction

Type 2 diabetes mellitus is a chronic disease that is closely linked to lifestyle factors (Centers for Disease Control and Prevention [CDC], 2022). Self-management of this condition requires changing behaviors and adhering to a complex therapeutic regimen (American Diabetes Association [ADA], 2022; Weber & Hassan, 2021).

Digital intervention, especially through mobile applications (apps), which are software applications for use on mobile devices such as smartphones and tablets (Diário da República, 2018), can be an effective strategy for managing chronic diseases (Lee et al., 2021). However, the vast commercial offer and lack of detailed information on available apps make it difficult for health professionals to advise on their use. The problem is compounded by the lack of scientific evidence and poor user satisfaction with many of these apps (Klemme et al., 2023). Therefore, the need and rationale for conducting this study are evident.

The defined objectives for this study are as follows: (1) to investigate the experiences of people with type 2 diabetes mellitus in using mobile applications to support disease and therapeutic regimen self-management; (2) to identify the needs for supporting disease and therapeutic regimen self-management as perceived by people with type 2 diabetes mellitus and that can be addressed by an app; (3) to explore the preferences of people with type 2 diabetes mellitus regarding the functionalities that can be incorporated into a mobile application to support disease and therapeutic regimen self-management.

Background

Type 2 diabetes mellitus has a high and increasing prevalence worldwide, leading to significant morbidity and mortality rates (Sociedade Portuguesa de Diabetologia [SPD], 2019). Therefore, it is crucial to emphasize the significance of lifestyle modifications in preventing and controlling diabetes, considering its global impact on people's lives and countries' economies (ADA, 2022; CDC, 2022). Diabetes management requires continuous and complex care to mitigate the associated multifactorial risks (ADA, 2022). According to Corbin and Strauss (1985, cited by Lee et al., 2021), diabetes requires a range of skills to manage its signs and symptoms, maintain motivation for lifestyle changes, prevent complications, and preserve psychosocial well-being. To support self-management, it is essential to develop strategies that address the difficulties people face when trying to achieve multiple changes simultaneously (ADA, 2022; Böhm et al., 2020).

Apps help people manage their disease by supporting them in controlling their therapeutic regimen and changing their lifestyles. Studies have shown that apps are effective in managing physiological aspects such as blood pressure and weight, as well as cognitive and behavioral aspects like adherence to medication, physical activity, and diet, and psychological aspects such as self-efficacy, motivation, and stress (Lauffenburger et al., 2021; Lee et al., 2021). Numerous diabetes-related apps are available on commercial platforms. However, many of these apps lack peer-reviewed publications and do not provide information on their development and evaluation. Additionally, there are no guidelines for healthcare professionals on how to use these tools, making it difficult to distinguish high-quality apps (Klemme et al., 2023; Lee et al., 2021). Furthermore, these tools often fail to fully represent people's preferences (Larbi et al., 2020). Diabetes apps often fail to integrate the various needs of people with diabetes into a single tool. For instance, they may focus solely on counting carbohydrates or recording blood glucose levels. Adu et al. (2018) identified that these apps may lack reminders and interoperability between systems and devices, while Klemme et al. (2023) highlighted the need for educational functions. Involving people with diabetes in the development of apps is crucial for successful implementation and continued use of these strategies (Klemme et al., 2023; Larbi et al., 2020).

Understanding the opinions and expectations of the target population is essential to ensure that the tool meets their actual needs and preferences. This premise, aligned with the current paradigm of client-centered care, allows a mobile app to be an effective support tool in managing the disease process and promoting behavioral change.

Research questions

1) What are the experiences of people with type 2 diabetes mellitus in using apps to support self-management of their disease and therapeutic regimen?
2) What are the self-management needs of people with type 2 diabetes mellitus that could be addressed by an app?
3) What functionalities should be included in an app to support disease and therapeutic regimen self-management, according to the preferences of people with type 2 diabetes mellitus?

Methodology

As part of a master's degree course, a descriptive qualitative study was conducted using the snowball sampling technique to select participants who met the following inclusion criteria: (1) adults over 18 years old; (2) diagnosed with type 2 diabetes mellitus for more than a year; and (3) habitual users of smartphones or tablets. Participants were recruited from the community, with a focus on a diabetic association in northern Portugal where the principal investigator conducts activities.

Data was collected between March and August 2019 using a sociodemographic and clinical questionnaire, as well as a semi-structured interview script designed for this study. Two pre-test interviews were conducted to confirm question comprehension. The interviews lasted an average of 25 minutes and were conducted in person by the principal investigator in a private location agreed

upon by both parties, either at the headquarters of the respective association or at the participants' homes, without any noise or interference. To capture the participants' complete discourse, the data was audio recorded, transcribed after each interview, and analyzed using content analysis (Bardin, 2009). The interviews were not repeated or resumed, and the original script was utilized.

The researchers used the criterion of theoretical saturation to limit data collection, resulting in a sample of 12 participants. The study's methodological quality was ensured, and research transparency was increased by adhering to the criteria outlined in the COnsolidated criteria for REporting Qualitative research (COREQ) checklist (Tong et al., 2007).

The research project obtained approval from the ethics committee of the institution where the master's course took place (flow 2019/638). To ensure free and informed consent, all participants signed a declaration of informed consent. To protect privacy, the information provided was treated confidentially by coding the documents and destroying them after data processing.

Results

The participants in the sample were predominantly men (92%) and employed (67%). Their mean age was 62.75 years (48-75; *SD* ± 9.33). Most participants had attended primary school (9; 75%), while 17% (2) had completed secondary school and only 8% (1) had attended higher education. The time since diabetes diagnosis ranged from 4 to 30 years, with an average of 17 years. Regarding drug therapy, 67% of the participants were prescribed only oral antidiabetics.

The interviews' content analysis identified six categories and their subcategories that characterize the experiences, needs, and preferences of people with type 2 diabetes concerning the use of an app to disease and therapeutic regimen self-management. The tables present the categories, subcategories, and units of analysis for each defined objective. The frequency of participant mentions is shown in brackets.

The facilitating factors category in Table 1 answers the research question about people's experiences using health-related apps.

Table 1

Experiences of people with type 2 diabetes mellitus in using mobile applications to support self-management

Facilitating factors	
Previous knowledge and experience (*n* = 4)	". . . I, for instance, used this [diabetes] app" (P11)
Perceived benefit (*n* = 9)	"Yes, I think it would be very interesting" (P2) "That would be a great advantage" (P7)
Usability (*n* = 4)	". . . but I couldn't install (the app) on my phone" (P2) ". . . there are people who don't have a good grasp [of mobile apps] and could have more difficulty understanding" (P5)
Remote monitoring (*n* = 2)	". . . we don't always find information or manage to go to the health center" (P2) "It would be nice to be able to deal with certain issues without having to go to the health center" (P3)

Despite using health-related apps, only one participant had used a DM-related app. Nonetheless, people see the benefit of using this type of tool as a remote monitoring strategy.

Similarly, the participants' speeches allowed us to identify three categories, shown in Table 2 - information content, self-determination, and emotional management, which represent the perceived needs of an app to support diabetes self-management.

Table 2

Perceived support needs for self-management of type 2 diabetes to be considered in a mobile application

Information content	
Diet (*n* = 7)	"It was important to talk about diet" (P4) "I wanted to conduct various tests to understand the relationship between certain foods and glycemia levels" (P7)
Physical exercise (*n* = 4)	"... according to the type of exercise, such as walking, running, or cycling, and the time spent, I could see the number of calories burned" (P11)
Disease identity (*n* = 2)	"Unless it evolves, right?" I am currently type 2, but could become type 1 later on" (P8)
Capillary blood glucose monitoring (*n* = 3)	"Many people have type 2 diabetes and may not know which values to follow" (P5) "Just now I asked for a machine to measure blood glucose and I can't find one for sale" (P7)
Sexual intercourse (*n* = 2)	"After being diagnosed with the disease and starting medication, I began to experience a lack of pleasure" (P7) "I think diabetes can affect other aspects of life... such as sexual intercourse" (P9)
Self-determination	
Setting objectives (*n* = 4)	"I aim to keep my glycated hemoglobin at 7%. Last year, it was at 7.2%. Maintaining this ratio is good for my health" (P3) "We set a goal to keep our blood glucose levels below a certain threshold, and the app alerted us when we exceeded it" (P4)
Motivation (*n* = 3)	"When you've had diabetes for a long time, sometimes it makes you want to give up and stop following everything" (P2) "Some people have a stronger personality and are able to set a goal and pursue it, but most don't have that ability. And that has to be worked on" (P7)
Emotional management (*n* = 4)	
"Stress influences diabetes a lot and I feel that when I'm more stressed or anxious, it's difficult to control my blood sugar... and then it takes a long time for it to stabilize again" (P2)	

Regarding preferences for app functionalities, participants valued interactive responses and multifunctional capacity for monitoring, recording, and analyzing data. The results, presented in Table 3, revealed two categories of preferences: Functions and Technical Features, and Health Professional.

Table 3

Preferences about the functionalities of a mobile application to support self-management of type 2 diabetes

Functions and technical features	
Multifunctionality (*n* = 5)	"I believe it should have multiple functions to make it broader and more comprehensive" (P8)
Monitoring results (*n* = 7)	" I track my steps and the distance I run using my cell phone" (P5)
Storage and memory (*n* = 7)	" All the results will be in one place" (P7) "This app shows my progress - how many times I reached my goal and how many times I didn't" (P11)
Data interpretation facilitators (*n* = 4)	"If the phone immediately displayed a high reading, it would be helpful" (P2)
Data input and connectivity (*n* = 2)	"If the app included a link to the [monitored] glycemic levels" (P3) "The app synchronizes with the clock" (P11)
Reminders and alerts (*n* = 4)	". . . remind them to eat on time, take their medication on time" (P6) "A reminder every two hours to eat and check your diabetes..." (P10)
Guidance and advice (*n* = 3)	"It should say *Do this* or *Do that*" (P2) "How to handle changes in sugar levels" (P4)
Health professional	
Relevance (*n* = 5)	"It would be great if it were possible. We might have to make a payment" (P7)
Information sharing (*n* = 6)	"It would be great to be able to write down a question when in doubt about a symptom and get an answer..." (P2) "It would be good to be able to ask questions and request medication, for example" P4)

Discussion

Understanding the needs and preferences of people with type 2 diabetes in using mobile applications to support the management of their disease is crucial. Participants acknowledge the usefulness of apps in diabetes self-management, despite admitting to having little experience with these tools. Although the participants were smartphone users, they did not make use of the full potential of these devices. While they used health-related apps in general, only one participant had used an app specifically related to diabetes. Research indicates that people are hesitant to associate technology with healthcare, and only a small percentage use apps related to their illness (Lauffenburger et al., 2021). The study participants have a low level of education. Poor functional literacy be related to poor digital literacy, which could explain their limited use of technological resources. The participants acknowledge their low digital skills, which can affect usability - the ease with which a person uses a device and how well it meets their needs - a crucial factor in user satisfaction and acceptance of an app (Böhm et al., 2020; Fischer & Kleen, 2021). However, some people recognize the advantages of using this tool, noting that apps provide prompt responses and can improve healthcare accessibility by overcoming barriers related to organization, geography, and time constraints.

Regarding perceived needs, participants primarily mentioned the need for information about the disease, its complications, and therapeutic regimen. It is important to provide easy access to content about diabetes and changes in daily life (Weber & Hassan, 2021) through tools that can be integrated into their daily routines (Lauffenburger et al., 2021). This study highlights the importance of understanding the pathophysiological process and potential complications of diabetes. Proper management of the therapeutic regimen requires a basic understanding of the disease (ADA, 2022). Participants reported difficulties with sexual intercourse, which were addressed in relation to the psychological component. This highlights the potential impact of decreased libido on quality of life (Shindel & Lue, 2021). Understanding the disease process and its potential complications is crucial for individuals to comprehend the impact of their actions and the need of making life changes. The most mentioned aspects related to lifestyle changes were diet, physical exercise, and monitoring capillary blood glucose levels. Participants expressed the need for a tool that could help them understand the relationship between diet, physical exercise, calorie intake and expenditure, and their glycemic levels. This knowledge enables people to comprehend the impact of their lifestyle on fluctuations in glycemic levels and develop better strategies to manage the disease (Lee et al., 2021). The educational functions of apps can complement the role of health professionals and improve self-management skills (Larbi et al., 2020). However, despite being a recognized need by several authors, the development of apps often neglects these functions (Baptista et al., 2020; Kabeza et al., 2020).

The participants identified another need related to self-determination. Modifying lifestyles to meet goals and manage health conditions can be a challenging process (Böhm

et al., 2020; Byrne et al., 2022). Setting individual goals can address the specific needs of each person, making them responsible for their own health (Lee et al., 2021). Active participation in decision-making and defining a health plan are signs of mastering self-management skills (Byrne et al., 2022).

Additionally, the emotional component of coping with and managing stress was also highlighted by the participants. The literature emphasizes the significance of managing the impact of chronic illness on psychosocial and emotional well-being (Byrne et al., 2022). Research has shown that stress management tools have a positive impact on diabetes control (Byrne et al., 2022). Therefore, when developing an app, it is necessary to consider the person's capacity for social interaction, expression of emotions, and coping strategies, even though participants had difficulty objectifying functions. Regarding people's preferences for app functionalities to support self-management of their illness, the participants show a preference for interactive and multifunctional tools that integrate functions for different aspects of self-management and allow for user choice. The results also highlight functions for monitoring physical exercise, diet, and biophysical parameters. In other studies, the most commonly used tools by people with diabetes are those for monitoring capillary blood glucose, counting carbohydrates, and engaging in physical activity (Baptista et al., 2020; Lee et al., 2021). The app's ability to record and store data is another aspect mentioned, indicating a preference for tools that allow data to be stored and history to be consulted, while also being able to synchronize with devices already in use, such as a capillary blood glucose meter. Some studies have identified manual data entry as a reason for abandoning the use of the app. Therefore, the ability to connect and automatically transmit data is an added value for the functionality and acceptance of this type of tool (Fischer & Kleen, 2021; Lee et al., 2021). Additionally, participants have mentioned the usefulness of reminder functions for medication intake and blood glucose monitoring. This tool is highly valued and widely used. It has been identified as missing from available apps (Baptista et al., 2020; Kabeza et al., 2020). Participants also mentioned the need for functions that facilitate the interpretation of results. Data analysis tools, such as graphs, visual markers, or color codes, enable people to compare their results with their goals and represent the impact of lifestyle on health indicators (Aida et al., 2020; Lee et al., 2021). In this context, guidelines and advice for health decision-making are also reported by the participants. Feedback messages, even in automated form, have been demonstrated to be effective in controlling the disease (Baptista et al., 2020; Lee et al., 2021). However, it is important to consider that being accompanied by a health professional allows for personalized care. People are more willing to use an app if it is recommended by a health professional (Fischer & Kleen, 2021). In this study, participants expressed an interest in sharing clinical information, clarifying doubts, and resolving bureaucratic issues, such as scheduling appointments with the professional who regularly accompanies them. Involving health professionals in app design and linking the app to the patient's diabetes care provider are crucial factors in ensuring the quality of information and support provided by diabetes apps (Krall et al., 2023; Lee et al., 2021).

Mobile applications can be helpful for individuals with low literacy levels. However, it is crucial to promote digital health literacy by educating people about accessing eHealth resources, searching for information online, and evaluating its quality (Kim & Xie, 2017). Interactive and multifunctional mobile applications can be an asset in accessing health care and modifying behaviors and lifestyles. They can provide information about the disease and therapeutic regimen, allowing the definition, monitoring, and analysis of results under the supervision of a health professional.

Limitations

The results cannot be generalized due to the limited study sample. The opinions and experiences expressed pertain to a group of individuals with low levels of education and digital literacy. It is important to note that including individuals with more advanced experience using this type of tool could provide a more comprehensive perspective on their needs and preferences. Additionally, the fact that 92% of the sample consisted of men may indicate a sample selection bias, possibly related to the snowball sampling method. While diabetes is more prevalent in men, future studies should aim to control for this. Perspectives and opinions on the needs and preferences related to an app may vary between genders, making it important to understand the results of a more representative group.

Conclusion

People are interested in using an app to support diabetes self-management and perceive the benefits of doing so, although they have little experience and knowledge of using health-related apps. The primary needs of individuals are related to disease information and therapeutic regimen management, including the ability to set personal goals and receive emotional support. Individuals tend to favor multifunctional and interactive applications to monitor and analyze their results while also providing guidance to aid in decision-making with regard to health professionals. The study answered the research questions it set out to answer and could serve as a springboard for further studies with representative samples of the population. This could lead to the development of more clinically relevant and client-centered self-management tools for type 2 diabetes. There is a growing interest in using mobile applications for self-management in health. It is essential to develop intervention programs to promote digital health literacy, alongside clinical research in this area. Introducing clinically effective and validated apps for the population can facilitate the support provided by health professionals to people with diabetes, ensuring personalized and continuous care.

Author contributions

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