Apps as a health education tool for people with diabetes mellitus: what is available in Portuguese?

Aplicativos como ferramenta de educação em saúde para portadores de diabetes mellitus: o que está disponível na língua portuguesa?

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Abstract

Health applications for mobile devices are an important tool for a health education to support the treatment of different diseases, such as diabetes mellitus (DM). In this sense, this research analyzes the functionalities of existing applications in Portuguese aimed at helping people with DM. A systematic search was performed to identify the applications by the descriptors "Diabetes control," "Diabetes," "Glucose," and "Insulin" in Android and iOS operating systems. A total of 576 applications were found, but only 63 (10.9%) met the inclusion criteria. According to their functionality, the apps presented the following possibilities of use: 13 are educational; 12 monitor physical activity; 18 contain a food diary; 28 count carbohydrates; 34 monitor insulin; 49 monitor blood glucose; 33 present graphs; 9 warn about the presence of hypo or hyperglycemia; 17 recall blood glucose collection; and 5 present culinary recipes. Functionalities that assist in behavior change and that individualize treatment strategies are still incipient. We suggest the development of auxiliary tools for interaction of applications with their users and the proof of their effectiveness.

Keywords: Diabetes Mellitus; Self-Management; Mobile Applications.

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Resumo

Os aplicativos de saúde para dispositivos móveis se revelam como uma ferramenta importante para a educação em saúde para apoiar o tratamento de diferentes doenças, como o diabetes mellitus (DM). Nesse sentido, esta pesquisa analisa as funcionalidades dos aplicativos existentes na língua portuguesa destinados a auxiliar pessoas com DM. Foi realizada uma busca sistemática para identificação dos aplicativos por meio dos indexadores "Controle de diabetes", "Diabetes", "Glicose" e "Insulina" nos sistemas operacionais Android e iOS. Foram encontrados 576 aplicativos, porém, apenas 63 (10,9%) atenderam aos critérios de inclusão. De acordo com sua funcionalidade, os aplicativos apresentaram as seguintes possibilidades de uso: 13 educativos; 12 monitoram atividade física; 18 contêm diário alimentar; 28 contam carboidratos; 34 monitoram a insulina; 49 monitoram a glicemia; 33 apresentam gráficos; 9 alertam sobre a presença de hipo ou hiperglicemia; 17 lembram coleta de glicemia; e 5 apresentaram receitas culinárias. As funcionalidades que auxiliam na mudança de comportamento e individualizam estratégias de tratamento ainda são incipientes. Sugere-se o desenvolvimento de ferramentas auxiliares para interação dos aplicativos com seus usuários e a comprovação da sua eficácia.

Palavras-chave: Diabetes Mellitus; Autogestão; Aplicativos Móveis.

Introduction

Diabetes mellitus (DM) is a chronic disease with an impact on Public Health, considered an ongoing epidemic. According to epidemiological data from 2019, at least 463 million people are diagnosed with diabetes in the world, and the projection for 2030 is 578 million, reaching 700 million in 2045, which represents an increase of 51% (IDF, 2019).

In Brazil, it is estimated that 9.1% of the adult population (≥ 18 years old) has DM, affecting approximately 35% of the population between 25 and 64 years old and 28.4% over 65 years old. The country is expected to have a population of approximately 11.3 million diabetics by 2030. It should be noted that older age groups will be the most affected, and half of this population will be unaware of the diagnosis (Brasil, 2021a; Macedo et al., 2017; Muzy et al., 2021).

DM is a disease that requires multidisciplinary treatment and continuous care; it integrates health education in its therapy to understand the importance of new practices and techniques, both for health professionals and for the people assisted. In line with this new way of looking at health, medication use, guided physical activities, self-control, self-care, psychosocial support, and healthy eating are still important. Therefore, it is essential that the information is practical and objective regarding day-to-day treatment, that is, there must be an interaction between the people assisted and primary health care (Arrais; Crotti, 2015).

Effective management of treatment, when not performed properly, negatively impacts the quality of life of the person with diabetes (Agarwal et al., 2019). Complications in the macro and microvascular systems related to the disease are the main cause of morbidity and mortality. They greatly impact not only financial burdens, but also socio-family relationships, thus becoming an onerous problem (Cole; Florez, 2020). An alternative to avoid complications is the training of individuals regarding the self-management of the disease, but first, it is necessary to train all those involved in the care and treatment of this disease, including people who are in the socio-family network of care. Thus, one can reduce traditional and cultural barriers during

treatment, such as adherence, time, distance, and costs (Agarwal et al., 2019; Whitehead; Seaton, 2016).

In Brazil, the follow-up of people with chronic diseases, as well as DM, is carried out by the Brazilian National Health System (SUS), by the Family Health Strategy (FHS). This form of organization ensures periodic consultations for the adequate treatment of diseases; however, access to trained professionals may be compromised by management failures that affect SUS throughout Brazil. A case study conducted in the 18th Regional Health Department of Paraná exemplifies this situation. In this study, Endocrinology was identified as a specialty categorized as non-existent/empty offer of care. Currently, therefore, there is a need for solutions that improve the quality of care, and the use of applications can contribute to the coverage of treatment and promotion of educational actions (Debon et al., 2020).

The expansion of the use of smartphones and tablets for the management of various day-to-day activities has provided a simultaneous growth in the use of health applications (Whitehead; Seaton, 2016). In 2019, 98.6% of people used mobile phones to access the internet in Brazil. In 2021, this number remained high, with 99.5% of accesses to the large network, but only 90.0% of Brazilian households had internet access. In total, according to data published in 2022, 96.3% of permanent private households have a mobile phone (IBGE, 2019). Due to the popularization of the use of mobile health applications (mHealth), there is a potential for them to become a tool for health education, disease self-management, remote monitoring, and dietary data collection (Bellei, 2020).

Moynihan et al. (2021), in a systematic review, identified that, with the Covid-19 pandemic, the use of health services decreased by approximately one third. Diseases that apparently had no severity had their follow-up postponed due to the need for social isolation initially imposed by the pandemic. This reduction is one of the justifications for the result observed in a study conducted in China (Cao; Zhang; Liu, 2022). According to the authors, access to mobile health applications generated greater satisfaction of health service users.

Despite the benefits that mHealth provides, it is possible to observe barriers in adherence to its use. Some obstacles are: language, literacy, availability, usability (accessible functions), and connectivity, in addition to the exclusion of vulnerable and older populations (Arrais; Crotti, 2015). Furthermore, it is not known whether the functionalities available in applications aimed at individuals with diabetes actually contribute to improvements in the management of the disease. Therefore, these functionalities, understood as resources related to DM control and health promotion, should provide greater autonomy to the patient in managing their health condition. We also highlight that individuals who do not access new technologies, in general, have acquaintances who can be in charge of helping them to update information, showing the protagonism of the person with diabetes and others involved in their care (Lima; Vieira, 2019).

Thus, considering the perspective of the high number of individuals with DM in Brazil, and the difficulties of accessing the Brazilian National Health System (SUS), it would be interesting if these people could count on the support of tools such as applications. First, for this to occur, an evaluation of the applications is necessary to understand what they offer and whether they are in accordance with the guidelines for self-care in the case of DM. This knowledge will both help users and health professionals in their indication. Thus, this research aimed to evaluate the content and functionalities of applications available in Portuguese for helping the monitoring of diabetes mellitus.

Methods

This is an exploratory, cross-sectional, and quali-quantitative study. A systematic search was carried out by the application stores Play Store, of the Android system, and Apple Store, of the iOS system, in the months of August, September, and October 2021, to identify free applications related to DM. To define the stages of search and analysis of applications, the flowchart model Prisma was used (Page et al., 2020). The research question was: what types of apps can people with diabetes and/or people involved in their care find available for free in the GooglePlay and Apple Store in Portuguese that help them deal with DM? Thus, the steps of identification, screening, eligibility, and inclusion of applications in the sample were carried out. Each of the steps will be detailed below.

Identification of applications

The identification of the applications that make up the sample occurred independently between two researchers (R1 and R2). For this purpose, the following keywords were used: "Diabetes control," "Diabetes," "Glycemia," and "Insulin". The choice of keywords occurred initially by a pilot study, when the keyword "diabetes" was used and other possibilities related to this descriptor were identified to access applications directed to people with diabetes. Subsequently, after a consensus, including two more researchers (R3 and R4), the keywords "Diabetes control," "Glycemia," and "Insulin" were added. The defined words were used in isolation and, moreover, the following inclusion criteria were considered to identify the applications: 1. Be present in the Android and iOS systems; 2. Have a Portuguese language version; 3. Have specific functionalities, as will be described below, to assist in the therapy of DM.

Screening and eligibility of applications

During the previously mentioned pilot study, some functionalities present in the applications were observed. Additionally, based on the *Journal of Primary Health Care - Strategies for the care of people with chronic diseases* from the Ministry of Health (MS) (Brazil, 2014), functionalities that help in the control of diabetes were defined. Thus, applications that offered the following options to their users were eligible: (1) blood glucose level recording; (2) insulin recording with their schedules and doses; (3) food recording; (4) carbohydrate intake recording; (5) physical activity recording; (6) graphic presentation of the records; (7) hypo and hyperglycemia alert; (8) recommendations, glucose measurement reminder; (9) recommendations, insulin or medication application reminder; (10) glycated hemoglobin (HbA1c) recording; (11) educational information on DM; and (12) culinary recipes for diabetics.

Identification of applications

After the evaluation of the functionalities of each application, still done independently, the data found by researchers R1 and R2 were compared and the divergences were evaluated in a consensus meeting with researcher R3, and when necessary with researcher R4. All the applications found were analyzed in the free version, observing, in each one, which functionalities were also offered in the paid version. In the aforementioned database, the functionalities were identified as present. In the case of applications that did not have their functionalities clearly described in the application store or in the app content itself, the information was sought from contact by electronic correspondence or application support. If no answers were obtained, these applications would be considered as no information, but not excluded from the sample.

Results

Figure 1 shows the search process for applications, as well as the number of applications excluded and included for evaluation.

Initially, 576 applications were identified, but only 63 were selected for analysis (Figure 1). Table 1 shows the characteristics of the applications included in the study. The analyzed applications, in addition to offering their services in Portuguese (Figure 2), are characterized by being mainly linked to the categories "Health and fitness" (44.4%; n=28) and "Medicine" (41.3%; n=26), favor the Android platform (61.9%; n=39) to the detriment of the iOS system (9.5%; n=6), and cost between U$ 0.54 and U$ 29.90, or be free (63.5%; n=40).

According to Table 2, the functionalities are incipient regarding the education of its users (20.6%; n=13) and association with physical activity (19.1%; n=12). Carbohydrate counting prevails as a measure of diet control (44.4%; n=28), as well as insulin monitoring or correction (54.0%; n=34) stands out as support for prescribed therapy. However, as expected, the recording of blood glucose for monitoring and verification (77.8%; n=49) of the patient's evolution predominated in this sense. Despite this functionality being present, only 14.3% (n=9) have hypoglycemia or hyperglycemia alert and indicate what to do in this situation. Furthermore, 30.2% (n=19) of the evaluated applications also offer the possibility of monitoring glycated hemoglobin (HbA1c). Finally, the use of graphic resources is shown as a tendency

to help in understanding the information provided (52.4%; n=33).

Other apps featured reminders for blood glucose measurement and insulin application/medication intake. Among those evaluated, it was possible to observe, on this aspect, a number of 49 and 17 applications, respectively.

All evaluated applications contained Portuguese as one of their languages, followed by English and Spanish, as shown in Figure 2.

Figure 1 – Flowchart of the search and analysis of apps available in Portuguese and intended to assist in the treatment of diabetes mellitus

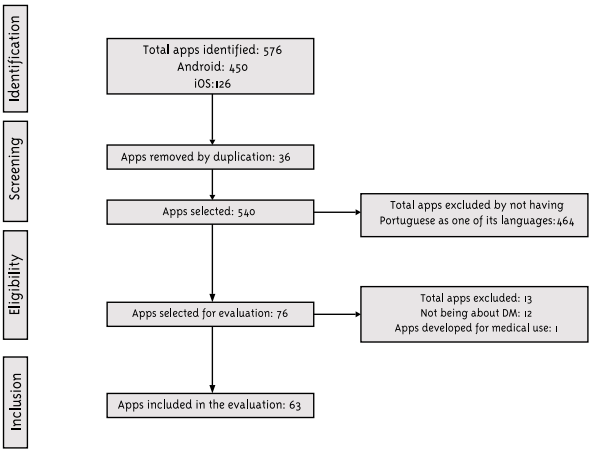


Table 1 – List of the main characteristics of the applications available in Portuguese and intended to assist in the treatment of diabetes mellitus

Variables	%	(n = 63)	Variables	%	(n = 63)
Number of languages evaluated			Country of development		
01 to 10	80.9	51	Brazil	25.3	16
11 to 20	15.9	10	United States	11.1	7
21 to 30	1.6	1	Others	20.6	13
> 30	1.6	1	No information	34.9	22
Prices			Evaluation		
Up to US$ 11.99	27	17	≤ 3.0	31.7	20
US$ 12 - 23.99	6.3	4	3.1 – 3.9	4.8	3
> US$ 24	3.2	2	≥ 4.0	49.2	31
			No rating	14.3	9
Average downloads			Age recommendation by app		
Up to 9,999	34.9	22	Free	61.9	39
10.000 – 50.999	23.8	15	> 4 years	15.9	10

continues...

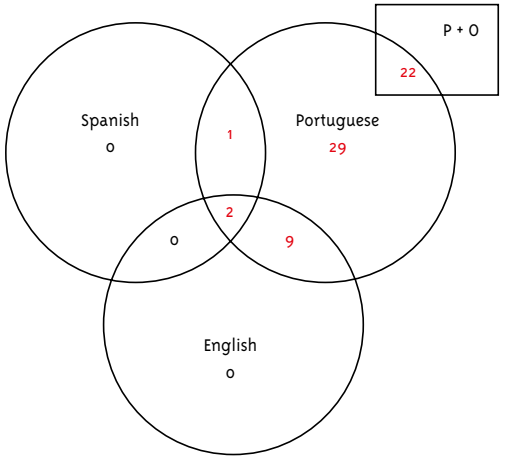
Table 1 – Continuation

Variables	%	(n = 63)	Variables	%	(n = 63)
V 51.000	31.8	20	> 12 years	12.7	8
No information	9.5	6	> 17 years	9.5	6
Number of apps by operating system			Category		
Android	61.9	39	Health and fitness	44.4	28
iOS	9.5	6	Medicine	41.3	26
Android + iOS	28.6	18	Medical care	4.8	3
Payment			Eating and drinking	4.8	3
Free	63.5	40	Education	1.6	1
Shopping inside app	36.5	23	Lifestyle	1.6	1

Table 2 – List of the functionalities evaluated on the applications available in Portuguese and intended to assist in the treatment of diabetes mellitus

Functionalities	%	N = 63
i) Blood glucose level recording	78	49
ii) Insulin recording with their schedules and doses	54	34
(iii) Food recording	29	18
iv) Carbohydrate intake recording	44	28
V) Physical activity recording	19	12
vi) Graphical presentation of records	52	33
(vii) Hypo and hyperglycemia alert	14	9
viii) Recommendations, glucose measurement reminder	27	17
ix) Recommendations, insulin or medication application reminder	78	49
(x) HbA1c recording	30	19
(xi) Educational information on DM	21	13
xii) Culinary recipes for diabetics	8	5

Figure 2 – Languages of the applications in Portuguese and intended to assist in the treatment of diabetes mellitus



P = Portuguese; S = Spanish; E = English; O = Other languages

Discussion

The characteristics identified suggest an important trend aimed at expanding the possibility of care in the follow-up of people with diabetes. Historically, SUS has faced difficulties in structuring specific services for this population. DM, as Non-Communicable Disease (NCD), is characterized by its complexity of treatment and multicausality, and requires a diversity of knowledge from health professionals, as well as family and friends involved in the care of people with diabetes (Guidoni et al., 2009; Bastos et al., 2011; Brazil, 2021b).

The COVID-19 pandemic has imposed a new *modus operandi* for health care services worldwide. Professionals and users of health systems were faced with the need to adapt to a new way of knowing how to do, signify, care for, and deal with the daily adversities of DM. Access to virtual platforms was one of these alternatives found, for example, for the nutritional and multidisciplinary care of children and adolescents with DM in Rio Grande de Sul (Silva et al. 2022). These platforms are also one of the facilitators pointed out in a systematic review that identified the simplification of the use of communication technologies as a factor for adherence to the treatment of people with DM assisted in Primary Health Care (PHC) (Brasil, 2021b).

The aforementioned situation demands practical resources for access to digital platforms. Operating systems fall under this aspect. According to this study, there was a greater presence of applications in the Android operating system (61.9%; n=39). This characteristic can be explained due to the wide variety of smartphones, such as Samsung, Motorola, and Xiaomi, that adopt it because it is an open-source platform. In the case of the iOS system, the only possibility of use is by Apple devices. Thus, in addition to the restriction regarding the variety of devices, there is a higher cost, normally associated with obtaining a device with access to the iOS system. Despite some technological advantages of the iOS system, it is possible that application developers see a greater potential for impact using the Android platform due to the lower investment usually required to purchase devices with this operating system (Leite; Macedo, 2018). It should also be considered that it is the most used operating system in the world, while the second is strictly used by Apple devices.

Still on accessibility and on the period that followed the beginning of the Covid-19 pandemic, health services, in general, had to deal with a growing demand for cases of the disease that concentrated most of the efforts of the sector. In addition, due to the isolation imposed on the entire population, many people with diabetes have been prevented from circulating and, consequently, from maintaining contact with health professionals responsible for monitoring their treatment. A study by Alromaihi et al. (2020) concluded, after following 1972 people with diabetes, that the use of technology with applications, accompanying the transfer of data from the glucometer, insulin pumps, or sensors of patients, can increase telemedicine, which, in turn, has become an essential service for primary health care (Alromaihi et al., 2020).

Given the evidence, the Brazilian Ministry of Health (MS) indicates applications with different uses, including therapeutic assistance for hypertension, among others. Suggestions for DM are: *Glic*, *One Droop*, *MySugr*, *Glucose Buddy*, available for Android and iOS. However, there is a lack of studies indicating the quality of the information accessed.

In the case of people with DM, it guides the use of some applications, but admits the difficulty of validating the consistency of what is available on platforms (Lima; Vieira, 2019).

mHealth is one of the most used and researched interventions with indication of good adherence, even with important barriers such as technological illiteracy, low level of health literacy, and little formal education. People who are exposed to actions of this nature, despite sometimes having access to the necessary devices, may feel uncomfortable and prefer more traditional approaches such as phone calls. Moreover, the impossibility of obtaining more updated devices with expanded storage capacity, as well as limited internet access, problems that increasingly distance themselves from the reality of the contemporary world, can still affect treatment adherence. Nevertheless, even with the aforementioned barriers, the use of technologies, such as applications, has been seen as a motivator for adherence to treatment. The greater automation of the tools used in the approach can generate less discomfort and overload of use, with a faster response from the health professional. As a benefit, the user of the system can make important changes in the management of their treatment in a reduced time. Other aspects described as potentiality of using applications are: graphical presentation of data; availability of collected data to health professionals and services; benefits in mobility and flexibility, such as in controlling where and when they are being monitored; among others (Brasil, 2021b).

Concerning the direct investment to obtain the application, there is no difference between the operating systems analyzed. The low cost verified for the use of the applications reveals that the intention of using them as important tools to assist in the management of the disease apparently does not find the cost as a barrier. However, the differences between the free and paid versions should also be noted (Arrais; Crotti, 2015).

Among the applications evaluated, some did not have information about their premium version and their respective values. Furthermore, all applications that had a version other than the free one offered additional features, such as removal of ads, the possibility of sending data to health professionals, synchronization of data with other devices, pdf reports, video of recipes, medication reminders, greater amount of food in the database, in addition to features that extend those already existing in the free version.

The amounts are monthly or in a single installment, giving lifetime access to the features of the paid version of the application. The *For diabetes* app has the lowest value in the premium version and the *My Glycemia* app has the highest value; among those that offered lifetime access, the lowest value version was found in the *Diabetes Diary* app. Despite the use of *mHealth* increasing exponentially, thanks to the benefits of its functionalities, it is important to highlight that less developed areas have people who are in digital exclusion. This prevents the adoption of applications, especially by individuals living in developing countries with restricted access to the internet (Chib; Lin, 2018).

Regarding the categories in which the analyzed applications belonged, a predominance of subcategories of the health care category was observed. They are: "Medicine," "Health & fitness," and "Medical care". In this category, applications with features such as goal setting, incorporation of evidence-based behavior change techniques, sharing statistics, among other functions are sought (Venkatakrishnan; Kaushik; Verma, 2020; Higgins, 2016). For DM, these are fundamental characteristics to assist in the treatment and self-management of the disease. However, one must observe the quality of the information provided. It is important, before the application is indicated, that the responsible health professional can test and validate its content (Lima; Vieira, 2019).

Good DM control requires the maintenance of a lifestyle with the adoption of healthy habits, such as: guided physical activities, correct use of medications – when necessary –, healthy eating, health education, and self-monitoring of blood glucose. In view of the potential of using technology as a way of promoting self-care behavior regarding the disease, the importance of using applications is noticeable (Veazie et al., 2018).

Regarding the functionalities, among the analyzed applications, 13 presented an educational system; the applications *MySugar* and *Índice e carga glicêmica: alimentos para diabetes*

presented the best rating. The educational system of the analyzed applications contained posts with important information to help in the self-care of patients with diabetes mellitus, indicating how to count carbohydrates, deal with episodes of hypo and hyperglycemia, and apply insulin. Among the functionalities, the educational resource is of fundamental importance, since it increases awareness about lifestyle change and DM self-management. In addition to education, management support by reminders positively influence the frequency of self-care behaviors among patients with the disease, thus improving the health of users (Krishna; Boren, 2008).

The reduced number of such functionality is alarming. The use of applications does not meet the demand for services that respect the SUS ethical-doctrinal principles of integrality, universality, and equity. Therefore, the importance of education for the use of applications by both users and health professionals is highlighted. Based on the knowledge of the content of the available applications, it is possible for the professional to consider the social context experienced by the person with DM and their family members, which directly or indirectly affects the adherence to treatment, as well as its success.

Among the applications analyzed, only 19% monitored physical activity, by counting steps and time of exercise performed. One can observe a significant relationship between the practice of insufficient physical activity and the diagnosis of Type 2 DM (Sami et al., 2017). The practice of exercise and regular physical activity, along with glycemic control, increases insulin sensitivity, improves aerobic capacity and muscle strength, and contributes to the decrease of intra-abdominal adipose tissue, which is known to be related to insulin resistance (Kumar et al., 2019; Sami et al., 2017).

Only five applications presented recipes intended for comorbidity, but without data on the yield and nutrients present. DM is a disease that has an adequate diet as one of its pillars of treatment, as already mentioned. Thus, the importance of dietary knowledge for the proper self-management of the disease is perceived, and clear information about food is necessary. The fact stands out especially in applications that have the purpose of sharing recipes of preparations aimed at this audience (Sami et al., 2017).

In 18 (27.7%) applications, it was possible to record individual food consumption daily. The use of the food diary helps the user to increase awareness of eating habits and to think critically about them, inducing better choices (Watanabe-ito; Kishi; Shimizu, 2020). From this resource, one can calculate the amount of carbohydrates (CHO) consumed. The carbohydrate counting strategy has been recommended by scientific societies in Brazil and around the world for more than 20 years. This strategy differs from the others, mainly by improving the quality of life and offering a range of food options for people with diabetes (SBD, 2016).

Despite the recommendation, among the applications analyzed, only 28 (44.4%) have the function of monitoring the amount of carbohydrate ingested according to the foods inserted. However, of this total, 16 (25.4%) require the individual to enter their daily consumption, that is, fill out a food diary. No application calculated an individual diet for its users. It should be noted that dietary prescription is a private activity of nutritionists. Therefore, individualized guidance should be obtained by care with this professional. The work of nutritionists, specifically for the individualization of the food plan according to the nutritional needs of the individual, is essential in the multiprofessional team (CFN, 2018).

Regarding insulin monitoring or correction, 34 (53.9%) applications had this feature. This function allows the user to record the amount of insulin applied, in addition to allowing the calculation of the dose of each meal, by the carbohydrate counting technique. Moreover, 49 (77.8%) applications featured the glucose monitoring function, which allows recording at different times of the day. The adequate management of insulin and carbohydrate intake culminates in the maintenance of adequate blood glucose levels, maintaining HbAlc levels 7%, with flexibility depending on age/life expectancy and complications such as comorbidities. Continuous hyperglycemia is associated with tissue damage by the production

of mitochondrial superoxide. Thus, applications become important allies in the management of the disease, which, when properly performed, prevents and delays complications of DM (Fasil; Biadgo; Abebe, 2019; Bahia; Almeida-Pititto, 2022).

It should be noted, however, that the "insulin monitoring/correction" functionality is an algorithm and should be used with caution, with the assistance of a trained professional (Wu et al., 2018). A study that analyzed the use of applications for insulin correction observed that, when this occurs with support from a health professional by text messages, over 6 months, it is possible to observe a reduction in glycated hemoglobin (HbA1c), and there is also a cost reduction in this distance support (Silva et al., 2020; Kumar et al., 2019).

Regarding the monitoring/estimation of HbA1c, it was observed that 30% of the applications had this feature. This includes the possibility of a faithful record from the result of the examination or an estimate of HbA1c from blood glucose monitoring. HbA1c is the product of an irreversible enzymatic binding of glucose to plasma proteins and reflects glucose levels in the previous 4-8 weeks. Although it has been found in a small number of applications, this functionality is important and useful, given that its monitoring allows identifying patients at risk of developing DM. Moreover, its adequate monitoring decreases the risk of developing microvascular complications (Sami et al., 2017).

Veazie et al. (2018) evaluated the effectiveness of some applications for the management of DM 1 and 2, and a statistically and clinically significant improvement in HbA1c values was observed. Additionally, improvement was observed in episodes of hypo and hyperglycemia compared to the control group, as well as improvement in knowledge about the disease and self-care behavior. The same study identified the degree of usability of the applications by their users, who classified them as moderate to good. Usability can be defined as an attribute of the acceptability that a user can have before the application and is associated with some main factors, namely: being easy to learn and use, as well as being tolerant to errors and pleasant to use.

The use of graphs to monitor the evolution of the indicators registered in the application in a given period was present in 33 (52.4%) applications. The use of visual aids in self-management is welcomed by users of the applications who want practical information, as mentioned. For users, the graph allows observing the trend of the behavior of the recorded data, facilitating the interpretation of the data and consequently self-management (Kayyali et al., 2017).

It was also possible to observe that only nine (14.3%) applications presented hypoglycemia or hyperglycemia alert and indicated what to do in this situation. Perhaps the low number of applications with this function suggests a profile of the applications to assist the health professional who accompanies the patient, seeking information only to subsidize their actions. Corroborates with this logic the fact that only 17 (26.9%) applications present reminders for insulin application/medication intake. At the same time, in a higher frequency, 49 (77.8%) presented glucose measurement reminders.

The reasonable number of applications (n=63) and their various functionalities aimed at people with diabetes reveals a technological advance in the area and important investments to improve the health of this population group. It is known that diabetes mellitus is a disease that requires strict control of blood glucose levels. When there is instability, the patient is subject to complications and mortality. Thus, despite the fact that glycemic control mostly occurs below ideal, it is of fundamental importance that the patient has information and resources available to perform it autonomously (Boyle et al., 2017).

A systematic review conducted in 2008, when the existence of applications was not common, revealed that the support carried out from functional aspects of the cell phone, such as short message system (SMS), voicemail, internet, or email enabled a facilitated communication between patient and professional. Therefore, it has brought better health results, since it provides treatment adjustments, decreasing the symptoms of diabetes (Krishna; Boren, 2008).

Subsequently, another research carried out in New Zealand investigated the most used or most desired functionalities among application users to carry out self-management of the disease. The following preferences were observed: glucose

and carbohydrate diary; insulin dose calculator; reminders; personal details and information about health status; appointment calendar; contact with medical staff; and dietary advice; so that the first two requirements were demanded in greater proportion (Boyle, 2017).

All 63 applications had Portuguese as one of their languages, as shown in Figure 3; of these, nine also contained English and 19 Spanish. The application with the highest number of languages was *Glucose Buddy*: *Diabetes*, containing 31 languages. Applications with only English or Spanish versions were not analyzed. All applications were analyzed for support, and among the 63, 48 offered support and 15 did not offer. It is observed that, curiously, comparing the applications in Portuguese, English, and Spanish, only the applications in Portuguese had versions only in that language. Possibly, English and Spanish versions are shared by many nations and their versions can be a second option to versions in other languages. The same situation is not observed with the Portuguese language, despite being spoken as a first language by more than 265 million people (Unesco, 2019).

Of the 63 applications analyzed, it was possible to observe 31 different languages available in the application *Glucose Buddy*, which is the rated app with the most languages. In second and third place were the apps *MySugar* and *Índice e Carga Glicêmica*, with versions in 24 and 15 languages, respectively. The remaining apps ranged from one-language versions to 14 languages. All applications contained Portuguese as one of their languages, 34.92% also contained Spanish and 50.79% English, thus achieving internationalization and facilitating applications such as *InsulinApp*, indicated by the Brazilian Diabetes Society, to reach other countries. This application was created to facilitate the medical prescription of insulin and has versions in English and Spanish, in addition to the Portuguese language. The idea arose from comments from professionals from other countries, in conferences and events, about the difficulty of using it only in Portuguese (SBD, 2016). However, it was excluded from the evaluation because it is an application aimed only at doctors. The app has more than 10 thousand downloads and is classified as free.

The classifications of the applications according to age groups (Table 1) showed the following criteria for differentiation: (1) free - applications without restriction; (2) over 4 years - does not contain offensive material; (3) over 9 years - may contain moderate or infrequent occurrences of realistic, animated, or fantasy violence, and content with infrequent or moderate adult, suggestive, or horror themes; (4) over 12 years - may contain frequent moderate language, frequent and intense realistic, animated, or fantasy violence, infrequent adult or suggestive themes, and simulation of games with money; and (5) over 17 years of age - may contain references to alcohol, tobacco, and drugs, as well as sexual content. Possibly, the need for classification was due to advertising served during the use of the application in its free version. Understanding that the criteria that limit access to the application do not condition its operation, most of them (n=39; 91.9%) were classified as free.

Still regarding age groups, it is important to highlight that, in the oldest ones, the developer should pay attention to some important factors inherent to the elderly public, which impact on the usability of the application, as previously mentioned. Aspects such as decreased vision, hearing, cognition, and memory, as well as lower problem-solving capacity and lower manual dexterity, are common in this age group; and despite this audience being the most affected by the disease, most applications are not adequate (Gao et al., 2017).

Regarding the rating of the applications, 14.3% did not have them, usually because they were recent in the store, as it was possible to observe during the research. In addition, 31% of applications had a rating of up to 3 stars, 5% between 3 and 4 stars, and 49% had above 4 stars in their user rating.

Among the applications with a rating of less than 3 stars, it was possible to identify some *bugs* that occur during use as a cause. For example, some functionalities do not work properly, as revealed by the comment of a user of the carbohydrate counting application of the Brazilian Diabetes Society (SBD, 2016): "the functionality to add meals is not working. After setting up the food, when you click save the meal simply disappears. It is not displayed on the home screen".

The use of applications, in general, as observed, has the potential to assist in the self-management of the disease. However, the difficulty in keeping track of information and the ability to learn to use the application (usability) are barriers often observed in the use of *mHealth.* Furthermore, there is a desire for practical and engaging resources, such as videos and games (Kayyali et al., 2017).

Limitations of the study

In this study, there was no deepening of the issues related to health education, since it aimed at a preliminary survey of applications to understand what dynamics are being adopted by developers. The use of applications does not meet the demand for services that respect the SUS ethical-doctrinal principles of integrality, universality, and equity. Therefore, the importance of education for the use of applications by both users and health professionals is highlighted. Based on the knowledge of the content of the available applications, it is possible for the professional to consider the social context experienced by the person with DM and their family members, which directly or indirectly affects the adherence to treatment, as well as its success.

In addition, the analysis of the applications that integrated the sample of this research was carried out mainly by the information provided by the stores of the operating systems: Android and iOS. The download was carried out only for the free applications. Thus, other investigations should be carried out with this objective as a sequence of the analyses developed here.

Targeted studies are needed to analyze the information given. After all, there is no standardization of diseases and treatments. Care should be personalized to meet the real needs of the person who needs it. Therefore, for the health professional to indicate an application, it is necessary to deeply know the disease, as well as the comorbidities.

Final considerations

The research carried out, within its proposal, showed what is available to increase the adherence of people with diabetes to treatment, especially in primary health care. As places that face routine difficulties, amplified with the Covid-19 pandemic, health professionals and users in general of health systems can find support in these tools, by the available resources identified, but they must be aware of their shortcomings. The applications available in Portuguese in the GooglePlay and Apple Stores for people with DM stand out for helping their user in the most objective follow-up of the disease. In this sense, the most available functionalities are the recording of blood glucose for monitoring and verification, monitoring or correction of insulin, and carbohydrate counting. Health education was neglected by the vast majority. Moreover, the applications found have many divergences of elements that are recommended to assist in the control of DM. If they are proven effective, they can contribute to the control of comorbidity and bring a higher quality of life for people with DM. Thus, the development of applications according to the needs of users is recommended. Gamification features and developers' concern with usability seem to be helpful. We recommend the conduction of observational studies to evaluate the influence of the use of each disease aid application in Brazil, since, although there are a vast number of applications, few are proven effective and recommended by entities such as SBD.

The study was able to capture important information for people with DM. The applied methodology allowed us to extract aspects about the quality of the application at the time of download. Thus, it allows developers to observe the potential and flaws of their applications, enabling advances in future versions.

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Authors' contribution

Lemos and Gebrim: data collection, data analysis, text production. Abreu and Dullius: data analysis, text production. Ginani: proposal conception, study design, data analysis, writing.All authors approved the final version submitted.

Received: 5/12/2023
Resubmitted: 5/12/2023
Approved: 5/17/2023