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REVIEW ARTICLE

Mobile applications to promote diabetic foot care: scoping review

Aplicativos móveis para promoção de cuidados com pé diabético: revisão de escopo

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ABSTRACT

Objective: To analyze applications on mobile platforms aimed at promoting diabetic foot care in terms of usability and available resources. **Method:** Scoping review of mobile applications available in online stores performed in January 2021. The applications included were downloaded and installed on a smartphone device. The evaluation of their usability was measured using the System Usability Scale and the Smartphone Usability questionnaiRE. **Results:** Eight applications were eligible, their development date was between 2015 and 2020, and seven were exclusive to Android. Usability by the Smartphone Usability questionnaiRE was level 50 (1), level 70 (1) and level 80 (6). As for the System Usability Scale, none of the applications reached a cutoff score. **Conclusion:** The evaluation of applications enabled the description and knowledge of functionalities, resources and usability. The scarcity of applications to promote foot care was identified.

Descriptors: Mobile Applications; Smartphone; Health Promotion; Diabetic Foot; Diabetes Mellitus.

RESUMO

Objetivo: Analisar aplicativos em plataformas móveis voltados à promoção de cuidados com o pé de diabéticos quanto à usabilidade e recursos disponíveis. **Método:** Revisão de escopo de aplicativos móveis disponíveis em lojas virtuais realizada em janeiro de 2021. Os aplicativos inclusos foram baixados e instalados em um aparelho *smartphone*. A avaliação de sua usabilidade foi mensurada por meio do questionário System Usability Scale e Smartphone Usability questionnaiRE. **Resultados:** Oito aplicativos foram elegíveis com data de desenvolvimento entre 2015 e 2020, sete eram exclusivos do Android. A usabilidade pelo Smartphone Usability questionnaiRE foi de nível 50 (1), nível 70 (1) e nível 80 (6). Já pelo System Usability Scale, nenhum dos aplicativos atingiu escore de corte. **Conclusão:** A avaliação dos aplicativos possibilitou a descrição e conhecimento das funcionalidades, recursos e usabilidade. Identificou-se a escassez de aplicativos para a promoção dos cuidados com os pés.

Descritores: Aplicativos Móveis; Smartphone; Promoção da Saúde; Pé Diabético; Diabetes Mellitus.

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How to cite this article: Mourão LF, Marques ADB, Moreira TMM, Oliveira SKP. Mobile applications to promote diabetic foot care: scoping review. Rev. Eletr. Enferm. [Internet]. 2022 [cited on: _____];24:69625. Available from: https://doi.org/10.5216/ree.v24.69625.

Received on: 07/11/2021. Accepted on: 12/20/2021. Available on: 03/31/2022.

INTRODUCTION

The increasing rates of Diabetes Mellitus (DM) have required actions of promotion, prevention, control and clinical management of the disease by health entities. In 2019, it was estimated that 11.3% of deaths worldwide were consequence of diabetes mellitus[1]. In this perspective, the International Diabetes Federation (IDF) projects that by 2045, there will be 700 million adults diagnosed with DM worldwide and Brazil will remain in 5th place in the ranking, with approximately 26 million people[2].

The macrovascular problems of DM include coronary heart disease, stroke and peripheral vascular disease, as well as microvascular dysfunctions such as kidney disease, retinopathy and neuropathy, which, together with lower limb amputations, are partly responsible for the stigma associated with this disease[2,3].

Diabetic foot is the most common, expensive, serious and preventable complication[2]. The risk of a person with DM having foot ulcers over the years is 30% and this can be responsible for 85% of causes of lower limb amputations[4]. In addition, it generates expenses of approximately R$ 18.2 million for the National Health Service (Brazilian *Sistema Único de Saude* — SUS)[5].

Chronic ulcers and amputations significantly reduce the quality of life and increase the risk of premature death. One of the factors that contributes to the significant increase in these rates is that only a third of professionals know how to recognize the signs of DM-related peripheral neuropathy. Thus, missed diagnoses favor high rates of morbidity and mortality[6].

Long-term efforts from patients, their healthcare providers and other interested parts have been required, although these are often ineffective due to complex factors, including challenges that patients may face in their daily work and lives[7]. Diabetic feet can result in an important economic, social and public health burden, especially in low-income communities, if there is no appropriate educational program[6].

Thus, DM self-management via emerging smart applications motivates people with DM to maintain a healthy lifestyle through frequent monitoring and intervention in the way of life, contributing to reduce complications. They have the desired resources for the meticulous planning of routine tasks that must be followed by these people[8].

New advances in the use of mobile and wireless technologies and handheld devices to improve healthcare processes and outcomes (mHealth) offer promising options for effective, low cost care and health promotion for patients with chronic illnesses such as diabetes. They can be an effective tool for patients and help to facilitate their interactions with healthcare providers, other patients and family members[9].

The platforms on DM have multiple applications available. Despite this considerable number of applications available to healthcare providers and patients, evidence on promoting care and preventing complications related to people with DM and diabetic foot are limited.

Based on this context and given the literature gap of review studies covering the types of mobile applications developed for the diabetic foot care of people with DM, the aim of this study is to analyze applications on mobile platforms focused on promoting foot care for people with diabetes mellitus regarding usability and available resources.

METHOD

This is a scoping review according to the review method proposed by the Joanna Briggs Institute (JBI). The aim of this method is to map the main concepts/definitions present in the literature, identify the types of evidence available in a given field and identify knowledge gaps[10].

For the construction of the research question, the PCC strategy for a scoping review was used: Population (P): People with diabetes mellitus; Concept (C): Promotion of foot care; Context (C): Mobile applications[10]. The following question was formulated: What mobile applications are available in virtual stores to promote foot care for people with diabetes mellitus?

Inclusion criteria were mobile devices (smartphone or tablet), free applications running on selected platforms (Android and iOS) that presented content or tools aimed at promoting diabetic foot care for people at any age, available in Portuguese, English or Spanish without time frame as to the period of publication. Applications with usage restrictions in Brazil and those with technical problems were excluded.

The survey of applications was performed in January 2021 in the two main virtual stores (Google Play store and Apple Store) of operating systems in Brazil using the search engines "diabetes", "diabetic foot", "care with feet" and "diabetic ulcer" in Portuguese, English and Spanish.

The applications that can be installed on iPhone, iPad or any other device with some version of the iOS operating system were catalogued. The apps available on Google Play and Apple Store were located in the "Medicine" and "Health and fitness" categories.

The Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) checklist was used to select the applications in virtual stores[11]. The database search using the top search terms resulted in 840 apps. However, after reviewing the titles, content description, theme, language and availability, 175 were screened. These were reviewed and 33 were selected and contrasted with the initial selection criteria. After downloading and installing the application for complete evaluation, only eight fully met the criteria and were included in the final review.

The included apps were installed on a smartphone device according to the operating system. For Android, the

Smartphone LG G4 Stylus HDTV H540T® was used, and for iOS, the iPhone 6 Apple 64GB® was used. Note that two independent researchers identified all discrepancies in relation to the selection, which were resolved by discussing with a third researcher.

Quality measures of the included mHealth applications were developed; their usability was evaluated with two separate questionnaires, star rating and number of downloads. The System Usability Scale (SUS) is used to evaluate products, services, hardware, software, websites and applications. The questionnaire consists of 10 questions and the user can answer from 1 to 5 for each; 1 means Completely disagree and 5 means Completely agree. To calculate usability, 1 is subtracted from the odd-response score and 5 is subtracted from the even-response score. To obtain the final average, the value found is multiplied by 2,5; the maximum SUS average is 68 points[12].

The second questionnaire was the Smartphone Usability questionnaire (SURe) version 1.0, based on the Item Response Theory (IRT) for the construction of its items. This questionnaire has 31 items and measures the usability of smartphone applications[13].

A synoptic chart previously prepared by the authors was used for data collection. It contained the following information: application/system/year, features, usability (SUS, SURe), star rating and downloads. Data were extracted and entered into Microsoft Excel®2010, where descriptive analysis was performed.

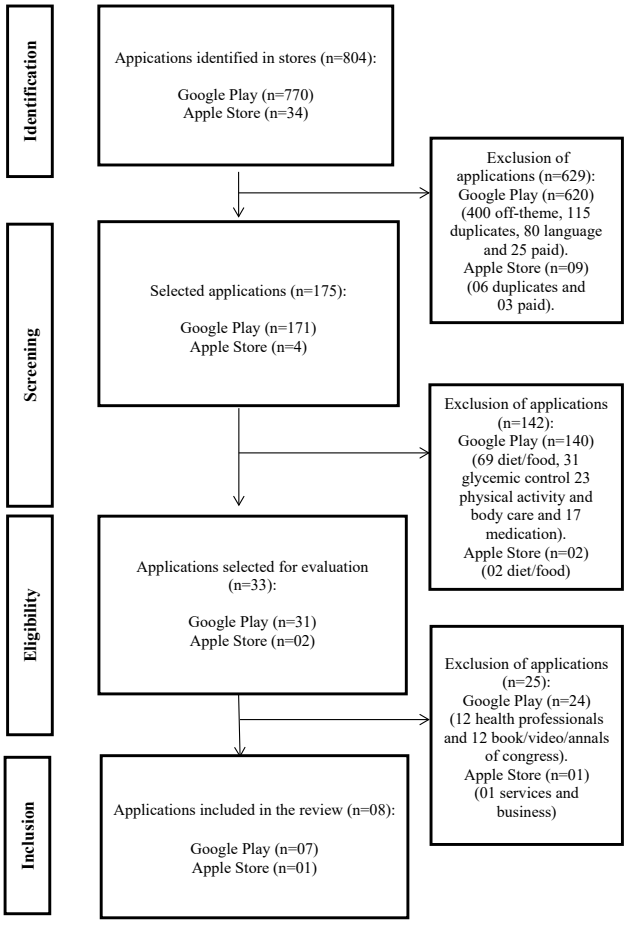

Figure 1. Flowchart of selection process of the application in virtual stores adapted from Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (n=08). Fortaleza, CE, Brazil, 2021.

RESULTS

After applying filters, eight applications were included in this study and analyzed, as shown in the flowchart (Figure 1).

Chart 1 presents the characterization of applications according to evaluation of the operating system, year, features, usability by SUS, SURe, star rating and number of downloads.

The eight applications (App 1 and App 8) included were developed between 2015 and 2020, seven (App 1, App 2, App 4, App 5, App 6, App 7, and App 8) were exclusive to Android, four (App 1, App 2, App 3, and App 5) available in English, two (App 6 and App 8) in Portuguese and two (App 4 and App 7) in Spanish. Internet access is required to use App 4, App 5, and App 6. The App 5 is for use by patients registered at the Specialized Center.

Applications were analyzed according to their scope and functionality. Chart 2 presents the operational characteristics and functions found in each application.

Applications were analyzed according to their scope and functionality. Features and functions are described below.

Based on the SURe analysis, one app (App 2) reached level 50, one level 70 (App 5), and the others (App 1, App 3, App 4, App 6, App 7, and App 8) reached level 80 of usability. Based on the SUS analysis, none of the applications reached the cutoff score of 68 points. The App 3 came closest with 65 points. Overall, the apps scored well.

None of the apps was rated five stars by users. The closest ones were App 1 with 4.5 stars and App 4 with 4.4 stars, and the others (App 2, App 3, App 5, App 6, App 7, and App 8) do not have user ratings. Regarding the number of downloads, which does not mean installation and consequently, usability of the application, the most downloaded application was App 4 with more than 1,000 downloads, and App 3 had no downloads up to the time of this review.

DISCUSSION

There are more than one million health and wellness applications available on Apple and Google app stores [14], with more than 300,000 focused on managing chronic diseases and/or conditions, and DM being the most common condition. The availability of health applications for

Chart 1. Characterization of applications based on operating system, features, usability by SUS, Smartphone Usability questionnaire, star rating and number of downloads. Fortaleza, CE, Brazil, 2021.

Application/system/year	Features	SUS	SURe	Star rating	Downloads
App 1: Diabetic foot and shoe Google Play – 2015 https://play.google.com/store/search?q=Diabetic%20foot%20and%20shoe&c=books&hl=af&gl=US	1. Assistance in checking diabetic feet. 2. Alarm setting to regularly check feet. 3. Assistance in checking orthopedic shoes. 4. The phone number of each specialist can be filled in. 5. Assistance in adapting to new shoes. 6. Information on risk and protection.	25	Level 80	4,5	>100
App 2: Signs & symptoms diabetic foot Google Play – 2015 https://play.google.com/store/apps/details?id=com.builtbydoctors.ssdiabeticfoot&hl=es_SV	1. Knowledge test (Quiz). 2. Record and track of diabetic foot levels using a graphical option. 3. Medication reminder.	22.5	Level 50	_	> 500
App 3: Diabetic foot screening for patients Apple Store – 2016 https://www.apple.com/br/search/Diabetic-foot-screening-for-patients?src=itunes_serp	1. Introduces a risk classification system and time of specialist consultation. 2. Foot exam educational video.	65	Level 80	_	_
App 4: Diabetic Foot Prevention Google Play – 2018 Atualizado em 2019 https://play.google.com/store/apps/details?id=makeit.com.mx.podologiasj&hl=en_AU&gl=US	1. Presents a questionnaire for the prevention of diabetic foot. 2. Identification of the risk of diabetic foot. 3. Periodic notifications to view general consensus on various topics to reduce the risk of diabetic foot.	42.5	Level 80	4,4	>1000
App 5: Shree diabetic and foot care Speciality Centre Google Play – 2019 Atualizado em 2020 https://play.google.com/store/apps/details?id=com.novosalus.aboutmyclinic.dr_rajendra_auti&hl=pt_BR&gl=US	1. Access your preferred clinic from anywhere. 2. Contents and resources for patient health education. 3. Appointment notifications and reminders. 4. Tools for health inquiries and consultation of the user's care team. 5. Recording tool for clinic events. 6. Frequently asked questions from patients and visitors. 7. Tool for information about clinic events and procedure costs.	32.5	Level 70	_	>100

Continue...

Chart 1. Continuation.

Application/system/year	Features	SUS	SURe	Star rating	Downloads
App 6: SoPeD Google Play – 2020 https://play.google.com/store/apps/details?id=br.com.soped&hl=pt_BR&gl=US	1. Features foot exercises only (does not focus on other aspects of the diabetic foot). 2. Presents a support questionnaire to assess the degree of neuropathy; 3. Diabetes Information; 4. E-mail notification for practice of exercises; 5. Tool to answer questions with experts and receive latest news about diabetes.	40	Level 80	_	>10
App 7: Mie pie diabético Google Play – 2020 https://play.google.com/store/apps/details?id=com.jose.quesada.piediabetico&hl=pt_BR&gl=US	1. Foot care tips.	50	Level 80	_	>100
App 8: PedCare Google Play – 2020 https://play.google.com/store/apps/details?id=br.com.pedcare&hl=pt_BR&gl=US	1. Daily foot care alarm. 2. Risk stratification alarm. 3. Daily care tips. 4. Healthy feet habits. 5. Tips for the correct nail clipping. 6. Wearing appropriate shoes. 7. Signs and symptoms of complications. 8. Exercises to improve foot circulation. 9. Quiz.	50	Level 80	_	>100

SUS: System Usability Scale; SURe: Smartphone Usability questionnaire.

Chart 2. Operational functionalities and resources of applications. Fortaleza, CE, Brazil, 2021.

Resources and/or functionalities	Applications
Recommendations for wearing suitable shoes, orthopedic shoes.	App 1, App 8
Care alarm, reminders.	App 1, App 2, App 8
Care checklist.	App 1
Foot care quiz game, self-assessment quiz.	App 2, App 4
Registration and monitoring of feet anatomical variations in graphical representation.	App 2
Foot risk stratification.	App 3
Educational video.	App 3
Risk classification of diabetic foot based on questionnaire responses, notifications and health consensus.	App 4
Tool to access the health team at the specialized center.	App 5
Tools to ask questions, schedule events at the specialized center and seek health information.	App 5
Self-assessment, foot and ankle exercises, information about DM, exercise notifications, questionnaire to identify the degree of neuropathy.	App 6
Foot care information.	App 2, App 7, App 8
Diabetic foot care and information, daily foot care alarm, risk stratification alarm, healthy foot habits, nail clipping, signs and symptoms of complications, and exercises to improve foot circulation.	App 2, App 8

smartphones allows people to manage their own health[13]. The Android platform stands out with the most expressive number of applications with greater number of resources. There is no significant difference regarding the total number of resources between free and paid applications (except for the Windows platform)[15].

Given the ambiguity in application selection and the wide variability in the main resources of applications recommended for DM, the management can be difficult for patients when selecting the most suitable application. Thus, it is important to include patients, health specialists, professional entities and policy makers to define the main resources that an application must have to be classified as "DM management", including the specification of minimum features[16].

The most important features for choosing mobile applications are the combination of functional and non-functional requirements for users. The functional aspect of user requirements refers to the functionality provided by applications and required by the user, such as weather forecasting and navigation. The non-functional aspect, on the other hand, is more about the relevant resources for the quality of applications, such as ease of use, user interface design, energy consumption, among others[17].

Several mobile applications for DM are inconsistent with recommendations of the area guidelines. A minimal set of resources for mobile applications has been designed, which includes the following for DM2: all types of tracking, meal tagging, food database, diet management, educational materials, healthy coping, risk reduction, problem solving, email, color coding, alerts, reminder, destination range setting, trend graph view, logbook view, numeric indicator view, customizable theme, preset notes and custom notes[18].

Mobile applications that include storage of data/graphs, exercise tracking, health/diet, reminders/alarms[19], resources to track blood glucose, blood pressure, nutritional value, and education about DM self-management are the most desirable according to the target public[20].

As the design and functionality of the application, as well as resources employed directly influence its usability, in a crowded market, those that consider quality stand out[21].

The Pictorial Identification Schema/Diabetes Self-care (PIS) is a graphical classification tool with six parameters (responsible promoters, services offered, search methods, application domain, expected users and qualifiers and quantifiers), each one with different attributes, to help DM patients identify reliable self-care applications[22].

In a review, a variety of applications aimed at the public with DM in general context was found, but those aimed at self-care promotion are restricted to basic functions (recording, representation and data delivery). On the other hand, a small quantity of advanced resources (those that need operating systems to perform tasks on devices) is implemented[22].

Applications that can be present everywhere, at low cost and convenient to use are more likely to be usable in low-income and needy areas because they offer effective, targeted and personalized communication for self-care promotion for patients and service providers. This increases the tendency to use them[23], as they promote better patient engagement and consequently, improve the effect of patient self-monitoring in DM treatment[24].

Given the rapid proliferation and large number of applications available, it is difficult for users and healthcare professionals to analyze their quality. In general, there is little information about the scope of the application other than the traditional one published on the application page, based on the quantity of stars. Thus, two different scales were used to assign a quality standard; the SUS (evaluates the general context)[12] and the SURe (specific for smartphones) [13], although in a broad aspect not restricted to the mHealth technology. Note that there is a specific rating scale for mobile health devices, the Mobile Application Rating Scale (MARS) [25], although still not validated and adapted to the Brazilian culture. Therefore, usability is a parameter to make a mobile application more usable[26].

Note that in Brazil there is only one application built and validated for the promotion of foot care of people with DM, with an overall usability average of 96.1 by the target audience, as evaluated through the SURe[27].

A limiting factor of the study was its restricted sample size that yields punctual results that cannot be generalized. In addition, the applications identified do not contemplate the basic requirements recommended by professional associations with regard to the promotion of foot care of people with DM and foot at risk.

CONCLUSION

The analysis of mobile applications for the promotion of foot care for people with DM and foot at risk enabled their description and knowledge of functionalities, resources and usability of the applications available in the Google Play store and Apple Store.

Through this study, we found a wide availability of applications related to disease control, although those designed to promote foot care are still scarce, given that the diabetic foot is an important preventable complication responsible for high rates of amputations, morbidity and mortality.

Thus, the importance the development of more specific mobile technological devices for the promotion of foot care for people with DM by researchers is emphasized, with the aim to intensify self-care and help with the knowledge of measures for the prevention of the diabetic foot, thereby empowering these people to health self-management and helping clinical management.

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